COMMUNITY ENERGY PLAN
BEAVER CREEK, Y.T.

and energy planning handbook for remote northern communities

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Prepared for:

Energy and Mines Branch
of the Department of Economic Development and Tourism
of the Yukon Government

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With a contribution from:

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EXECUTIVE SUMMARY

PART 1

I INTRODUCTION

Acres International Limited and Arctech Community Energy Research Associates were retained to assist the community of Beaver Creek, Yukon in the application of a remote community energy planning program. While the study process concentrated on the problems and opportunities apparent in Beaver Creek, it is the intent that the energy planning process developed for that community can be adopted by other northern communities as well.

This energy plan for Beaver Creek is comprised of three principal areas of analysis. The initial endeavors in the community involved an identification of current energy consumption patterns through the analysis of historical fuel purchase records and individual surveys of the energy performance characteristics of all buildings in Beaver Creek. The next phase of the study, which was based on an analysis of the building performance data collected through the surveys, was an assessment of the means for conserving energy and reducing energy consumption through the application of various proven techniques for rendering buildings more energy efficient. Finally, the various means for utilizing alternative resources to supply the energy requirements of the community were investigated.

II ENERGY CONSUMPTION PROFILE

Over 862,000 litres of fuel oil with a value of about $396,500 are consumed annually in Beaver Creek. Of this, 47% is consumed to generate electricity in the community.

The other 53% is primarily utilized for space heating of buildings. To further disaggregate and understand the causes of energy consumption, the survey data for each building was utilized to calculate a retrofit potential index for the structure. This index is designed to indicate those buildings which have high energy requirements and are operating relatively inefficiently. These buildings are highlighted because they have the greatest potential for realizing savings in energy consumption through conservation.

In general, many of the buildings in Beaver Creek were found to be utilizing more energy than necessary to achieve desired comfort levels. Virtually all buildings in Beaver Creek could achieve significant reductions in space heat energy requirements through the sealing of air leaks in the building envelope and reduction of the thermal conductivity of the building through the retrofit of additional insulation. It is noted that air sealing is especially critical in a climate such as that experienced in Beaver Creek because the installation of additional insulation alone may merely exacerbate moisture damage problems in the buildings if effective vapour barriers are not first installed.

It was also determined that significant energy and cost savings could be achieved through very low cost means in the area of domestic hot water energy consumption. Most buildings in Beaver Creek could benefit almost immediately simply by lowering the temperature of the hot water heater, installing low flow shower heads, and insulating the water tank and the water pipes.

Improvements to oil furnace combustion efficiency ratings could also have significant impact on the amount of oil consumed in the community. Very few furnaces surveyed during the course of this study were operating near their efficiency capabilities. With good tuning practices, seasonal oil furnace efficiency should achieve about 75%. However, many of the oil heating systems in Beaver Creek showed an efficiency of less than 70%. General maintenance and tuning of the furnaces, application of more efficient combustion nozzles, installation of retention head burners and/or the use of automatic stack dampers are some of the measures available for increasing furnace efficiencies.

The conservation measures described in detail in this report would result in the saving of as much as 32% of the fuel oil presently used for space heating in Beaver Creek. In addition, the DHW conservation measures would serve to reduce some of the oil presently consumed for electrical generation, since most of the hot water heaters in the community are electric. Most of the conservation measures recommended are low cost provided local labour is utilized. Most of the conservation measures are simple enough that the building owner or operator could readily do the work required. For the bulk of these recommendations, the economic pay back period is exceedingly short and there is no doubt that these are fully justified.

III ENERGY SUPPLY ALTERNATIVES

A number of alternative resources and energy supply technologies were investigated for their applicability in Beaver Creek. These alternatives were assessed in terms of the technical feasibility, the extent and reliability of supply, the economic feasibility and the significance of the alternative to the community as a whole. The viable alternatives which could significantly reduce oil consumption in Beaver Creek were found to be the following:

Wood Fuel

Sufficient wood is available in the region surrounding Beaver Creek for it to become the primary fuel for space heating in the residential sector. Reasonably efficient wood-fired energy systems are available for such applications and the resulting delivered cost of useable energy is comparable to that for oil. If the community develops an efficient wood collection and distribution system, the benefits of using wood fuel become even more attractive. However, even if a community-wide initiative toward wood burning does not materialize, the alternative is sufficiently attractive such that individual building owners/operators should be encouraged to pursue wood-fired space heating.

Waste Oil Recovery

It is estimated that about 9,000 litres of useable waste oil is being discarded in Beaver Creek annually. The bulk of this comes from the Government of Yukon garage facility. Waste oil can be burned much like fuel oil in specially designed furnaces. The Government of Yukon garage itself is a large consumer of fuel oil and would be a logical candidate for the utilization of oil waste to reduce heating oil consumption. The annual savings on fuel oil purchases for the garage are estimated at

$4,000. Capital costs for the collection tank and furnace would be about $11,000. Thus, the pay back period is less than three years for this system.

Diesel Generator Waste Heat

On a larger scale, the installation of a diesel generator waste heat recovery system and district hot water distribution system appears economically feasible. A suggested layout for the central plant system and distribution system is provided. Basically, it is recommended that virtually all of the larger buildings in the community with the exception of the customs building which is some distance away from the town, be connected to the distribution system.

The energy recoverable from the diesel generators and useable in the community is found to be in excess of the equivalent of 144,000 litres of fuel oil annually. Installation costs for the system are estimated at approximately $300,000 and pay back of these capital costs was found to be a period of about 5.5 years. Obviously, this system would result in substantial reductions in oil consumption in Beaver Creek.

Solar Energy

Increased utilization of passive solar energy is feasible and recommended in Beaver Creek. The opportunities for employing solar energy in existing buildings is probably limited due to the costs of renovations. However, all new buildings can achieve substantial energy savings if they are designed to maximize solar gains. The costs associated with such designs are relatively nominal for new buildings.

Other alternative energy supplies considered in the course of this study were not found to be viable in the Beaver Creek setting. The difficulties associated with these alternatives are documented in the report.

PART 2

The second part of the study involved developing a ten-step procedure which can be used as a guide to secure the energy future of any northern community. The steps are:

1. Establish an energy management/planning committee.
2. Quantify historic energy demand.
3. Determine efficiency rating for individual buildings.
4. Identify sources of energy waste.
5. Decide how to improve efficiency and reduce waste.
6. Identify, develop and utilize local resources.
7. Re-evaluate energy demand after conservation.
8. Assess available energy alternatives.
9. Analyze realistic energy alternatives.
10. Develop an ongoing energy accounting system.

The study was undertaken for the government of the Yukon with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

PLAN D'ÉCONOMIE D'ÉNERGIE POUR BEAVER CREEK (YUKON)

et manuel de planification énergétique pour les collectivités éloignées du Nord

Résumé

A. BEAVER CREEK

I. Introduction

Acres International Limited et Arctech Community Energy Research Associates ont été choisis pour aider la collectivité de Beaver Creek au Yukon à préparer un programme de planification énergétique à l'intention des collectivités éloignées. Bien que cette étude mette l'accent sur les problèmes et possibilités particulières à Beaver Creek, les méthodes de planification énergétiques qui ont été mises au point pour cette collectivité devraient pouvoir s'appliquer aux autres collectivités du Nord.

Ce plan énergétique destiné à Beaver Creek touche à trois principaux domaines d'analyse. L'entreprise a d'abord consisté à établir les modes de consommation actuels de la collectivité en faisant l'analyse historique des achats de combustible et en effectuant des enquêtes individuelles portant sur les caractéristiques énergétiques de toutes les constructions de Beaver Creek. La deuxième phase de l'étude qui était fondée sur une analyse des données énergétiques des constructions recueillies au cours des enquêtes, a consisté à évaluer les moyens d'économiser l'énergie et d'en réduire la consommation par l'application de diverses techniques éprouvées, utilisées pour rendre les constructions énergétiquement plus efficaces. Enfin, les diverses façons d'utiliser les ressources de remplacement pour répondre aux besoins en énergie de la collectivité ont été analysées.

II. Profil de consommation d'énergie

À Beaver Creek, il se consomme plus de 862 000 litres de mazout par année ce que coûte environ 396 500 $. Près de la moitié de cette quantité (47%) sert à produire de l'électricité pour la collectivité. Le reste (53%) sert surtout à chauffer les constructions. Pour disséquer et comprendre les causes sous-jacentes à la consommation d'énergie, les résultats de l'étude de chaque construction ont été utilisés pour établir l'indice du potentiel d'amélioration énergétique. Cet indice sert à repérer les constructions énergivores dont le chauffage est relativement inefficace. Ces constructions retiennent notre attention, car ce sont elles qui présentent le plus de possibilités en matière d'économies d'énergie.

En général, il ressort de cette étude que de nombreuses constructions de Beaver Creek utilisent plus d'énergie que nécessaire pour atteindre le niveau de confort désiré. Dans le cas de presque toutes les constructions de Beaver Creek la quantité d'énergie nécessaire au chauffage pourrait être réduite considérablement si les fuites d'air étaient colmatées et si l'on augmentait l'isolation de façon à réduire la conductibilité thermique. Soulignons que le colmatage est particulièrement important dans un climat tel que celui que connaît Beaver Creek, étant donné que la pose d'isolants supplémentaire, sans l'installation préalable de pare-vapeur efficaces peut avoir pour effet d'accentuer les problèmes causés par l'humidité dans les constructions.

Il ressort également de cette étude que des économies élevées en énergie et en coûts pourraient être réalisées en utilisant des moyens très peu coûteux dans le secteur de la consommation d'énergie liée à l'eau chaude domestique. En effet, la plupart des constructions de Beaver Creek pourraient faire des économies presque immédiates en réduisant simplement la température du réservoir à eau chaude, en installant des pommes de douche à faible écoulement et en isolant le réservoir et les conduites d'eau chaude.

Le fait d'améliorer le rendement des chaudières au mazout pourrait se traduire par une importante réduction de la consommation de mazout de cette collectivité. Les enquêtes ont révélé que très peu de chaudières fournissent un rendement conforme à leur capacité. En faisant les réglages appropriés, le rendement saisonnier des chaudières au mazout devrait atteindre environ 75%. Cependant, nombre d'appareils de chauffage au mazout ont montré un rendement inférieur à 70%. Parmi les mesures à prendre pour augmenter l'efficacité des chaudières, mentionnons l'entretien général et le réglage, la pose d'ajutages de combustion plus efficaces, l'installation de têtes de brûleur et l'utilisation de registres de cheminée automatiques.

L'application des mesures d'économies d'énergie, décrites en détail dans ce rapport, entraînerait une réduction de 32% de la consommation actuelle de mazout utilisé pour chauffer les constructions de Beaver Creek. En outre, étant donné que la plupart des chauffe-eau de l'endroit sont électriques, l'application des mesures d'économie d'énergie relatives à l'eau chaude de district contribuerait à réduire une partie de la quantité de pétrole actuellement utilisée pour produire de l'électricité. La plupart des mesures d'économie d'énergie recommandées ne sont pas coûteuses pour autant qu'on utilise la main-d'oeuvre locale. De plus, elles sont d'une simplicité telle que le propriétaire ou le gérant de la construction pourrait être en mesure d'effectuer lui-même les travaux requis. La plupart de ces recommandations visent des mesures dont les coûts peuvent s'amortir en un rien de temps et elles sont sans contredit tout à fait justifiables.

III. Autres possibilités d'approvisionnement en énergie

Un certain nombre de ressources de remplacement et de techniques d'alimentation en énergie ont été analysées en tenant compte de la situation particulière de Beaver Creek. Ces possibilités de remplacement ont été évaluées en fonction des critères suivants: faisabilité, étendue et fiabilité de la source d'approvisionnement, rentabilité et perception de la source de remplacement par la collectivité dans son ensemble. Les sources d'énergie et les techniques de remplacement viables qui pourraient réduire sensiblement la consommation de mazout à Beaver Creek sont les suivantes:

Bois de chauffage

Il y a suffisamment de bois de chauffage dans la région de Beaver Creek pour que cette source devienne le premier combustible en importance pour le chauffage des habitations du secteur résidentiel. Il existe des systèmes raisonnablement efficaces de chauffage au bois et le coût résultant de l'utilisation de cette énergie est comparable à celui du mazout. Si la collectivité mettait au point un système efficace de ramassage et de distribution du bois, l'utilisation du bois de chauffage offrirait des perspectives encore plus attrayantes. Cependant, même si la collectivité ne réussit pas à faire adopter le bois de chauffage par tous les habitants, cette possibilité demeure néanmoins suffisamment intéressante pour que les propriétaires ou les exploitants d'immeubles reçoivent l'encouragement individuel nécessaire pour chauffer au bois.

Récupération de l'huile usée

On estime à environ 9 000 litres l'huile usée récupérable qui est jetée chaque année à Beaver Creek. La plus grande partie de cette huile provient du garage du gouvernement du Yukon. L'huile usée peut être brûlée comme le mazout dans des chaudières spécialement conçues à cet effet. Le garage du gouvernement du Yukon est lui-même un grand consommateur de mazout et serait le candidat tout désigné pour utiliser l'huile usée et réduire ainsi sa consommation de mazout. On estime que le garage économiserait ainsi 4 000 $ par année sur ses achats de mazout. Les coûts en capital engagés pour le réservoir d'entreposage et le chaudière s'élèveraient à environ 11 000 $ et leur amortissement se ferait en moins de trois ans.

Chaleur perdue de groupes diesel

À une plus grande échelle, il semble rentable d'installer un système de récupération de la chaleur perdue provenant de groupes diesel et un système de distribution de l'eau chaude à l'échelle du district. Le plan proposé concernant un système central et un système de distribution est présenté dans ce document. Fondamentalement, il est recommandé que presque toutes les constructions importantes de la collectivité, à l'exception du bâtiment des douanes situé à l'extérieur de la ville, soient branchées sur le système de distribution.

L'énergie récupérable à partir des groupes diesel et utilisable par la collectivité dépasserait l'équivalent de 144 000 litres de mazout par année. Les coûts d'installation du système s'élèveraient à environ 300 000 $ et le délai d'amortissement serait d'environ 5,5 ans. Il est évident que ce système entraînerait des réductions importantes de consommation de mazout à Beaver Creek.

Énergie solaire

Il est possible et recommandé d'accroître l'utilisation de l'énergie solaire passive à Beaver Creek. Les possibilités de récupérer l'énergie solaire dans les constructions existantes sont probablement limitées par les coûts qu'entraîneraient les rénovations. Cependant, toutes les nouvelles constructions peuvent réaliser des économies d'énergie substantielles si elles sont conçues pour tirer parti au maximum de l'énergie solaire.

Les coûts liés à de telles conceptions sont relativement minimes en ce qui concerne les nouvelles constructions.

Les autres sources d'énergie de remplacement qui ont fait l'objet d'une analyse dans le cadre de cette étude ne se sont pas révélées viables dans le contexte de Beaver Creek. Les difficultés qu'elles soulèvent sont énumérées dans ce rapport.

B. MANUEL DE PLANIFICATION ÉNERGÉTIQUE

La deuxième partie de l'étude comporte un manuel où l'on retrouve une méthode en dix étapes qui peut être utilisée pour assurer l'avenir énergétique de toute collectivité nordique. Ces étapes sont les suivantes:

1. Former un comité de gestion et de planification énergétiques.
2. Quantifier les besoins d'énergie jusqu'à ce jour.
3. Déterminer le taux de rendement énergétique de chaque construction.
4. Découvrir les sources de perte d'énergie.
5. Décider de la façon d'améliorer le rendement et de réduire les pertes.
6. Repérer, mettre en valeur et utiliser les ressources locales.
7. Réévaluer les besoins en énergie après application des méthodes d'économie d'énergie.
8. Évaluer les possibilités de remplacement d'énergie disponibles.
9. Analyser les possibilités réalistes de remplacement d'énergie.
10. Mettre au point un système permanent de comptabilisation des économies d'énergie.

Cette étude a été réalisée pour le gouvernement du Yukon grâce à une contribution du Programme de démonstration dans les collectivités éloignées mis sur pied par Énergie, Mines et Ressources Canada.

PART 1
COMMUNITY ENERGY PLAN, BEAVER CREEK, YUKON

1.0 INTRODUCTION

1.1 Scope of Study and Objectives

On behalf of the community of Beaver Creek, the Government of Yukon Energy & Mines Branch engaged Acres International Limited and Arctech Community Energy Research Associates to develop a community energy plan. Funding for the project was provided by Energy, Mines and Resources Canada through the Remote Community Demonstration Program (RCDP).

The energy planning program conducted in Beaver Creek serves as a practical application of a remote community energy planning process, which can be adopted by other northern communities. It is intended that the Beaver Creek experience will demonstrate, to community leaders and officials in other northern settlements, the methods (and the benefits) of community energy planning.

This report addresses the specific findings and recommendations relevant to Beaver Creek. It documents the analysis and procedures followed by the study team in developing an energy plan for Beaver Creek. The report can also become a blueprint for future energy conservation and oil reduction efforts in the community. This volume utilizes the data compiled in the Beaver Creek Phase I Report which details the building energy surveys and conservation recommendations for the community.

1.2 Overview of Planning Process

As noted above, the assignment given to Acres and Arctech involved both the development of a remote community energy planning process as well as the application of that process in Beaver Creek. As a result, a companion volume has been produced titled "Northern Community Energy Planning Handbook" which provides a step-by-step guide for pursuing energy planning in other communities. The planning process described in the Handbook documents the methodology which was developed in Beaver Creek.

Figure 1-1 outlines the community energy planning process. Step 1 involves the initiation of a formal energy planning exercise through the formation of a committee made up of the key participants in the community.

Steps 2 through 6 entail the compilation of historical energy consumption records, the analysis of individual buildings through energy surveys, assessment of the buildings' energy performance, and the development of appropriate energy conservation measures for individual buildings. These steps of the planning process in Beaver Creek are detailed in the Phase I report. The principal findings and conclusions of that report are also included in Section 2.0 - Summary Energy Profile and 3.0 - Energy Conservation Opportunities in this report.

Section 4.0 - Energy Resource and Supply Alternatives are addressed in Steps 7 to 10 of the planning outline. This Section deals with the assessment of post-conservation demands and energy supply options. Implementation considerations for both conservation measures and alternatives are discussed in Sections 3.0, 4.0 and 5.0 of this report.

TEN STEPS TO COMMUNITY ENERGY PLANNING

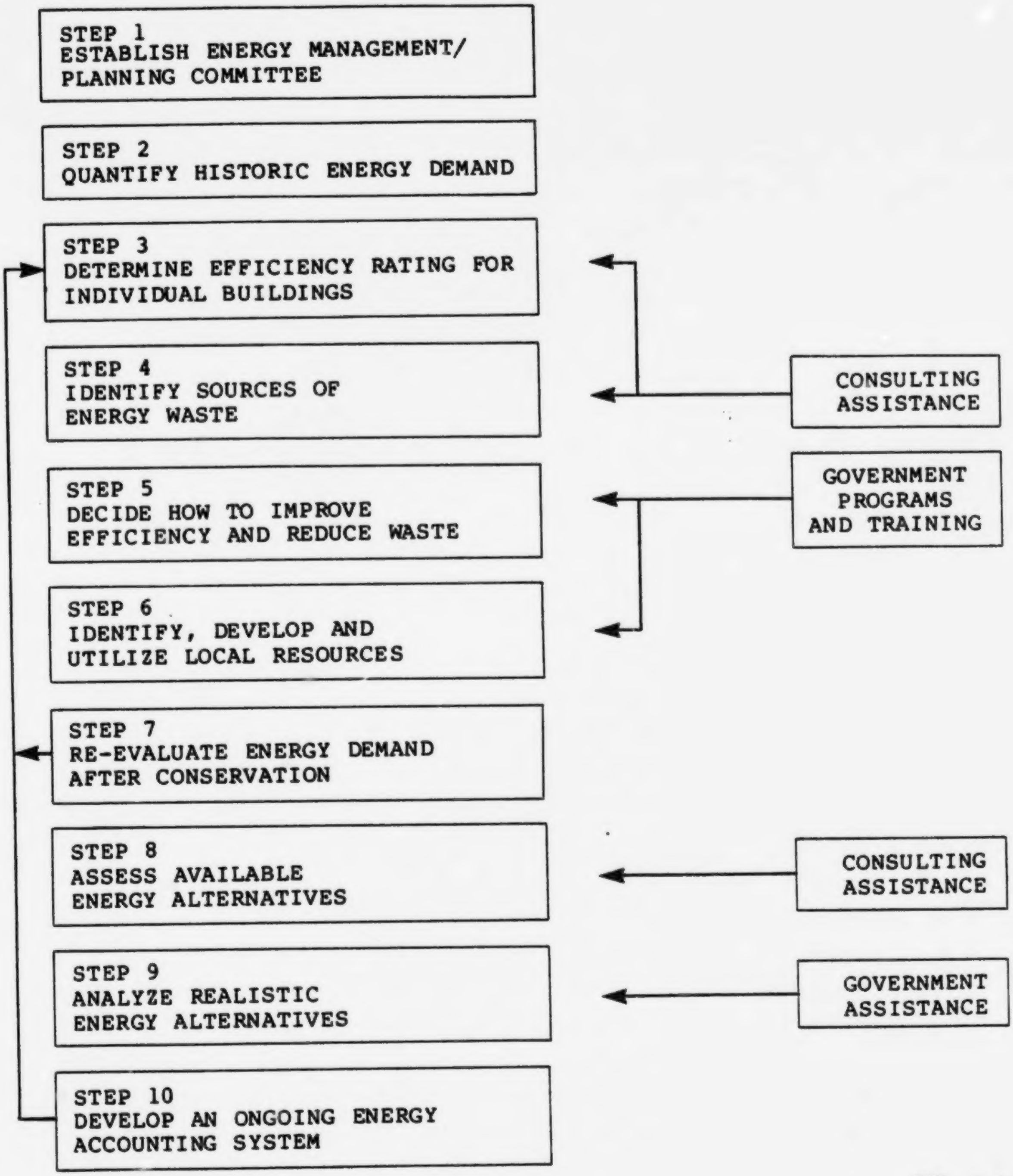

STEP 1
ESTABLISH ENERGY MANAGEMENT/ PLANNING COMMITTEE
STEP 2
QUANTIFY HISTORIC ENERGY DEMAND
STEP 3
DETERMINE EFFICIENCY RATING FOR INDIVIDUAL BUILDINGS
STEP 4
IDENTIFY SOURCES OF ENERGY WASTE
STEP 5
DECIDE HOW TO IMPROVE EFFICIENCY AND REDUCE WASTE
STEP 6
IDENTIFY, DEVELOP AND UTILIZE LOCAL RESOURCES
STEP 7
RE-EVALUATE ENERGY DEMAND AFTER CONSERVATION
STEP 8
ASSESS AVAILABLE ENERGY ALTERNATIVES
STEP 9
ANALYZE REALISTIC ENERGY ALTERNATIVES
STEP 10
DEVELOP AN ONGOING ENERGY ACCOUNTING SYSTEM
CONSULTING ASSISTANCE
GOVERNMENT PROGRAMS AND TRAINING
CONSULTING ASSISTANCE
GOVERNMENT ASSISTANCE

FIG. 1-1

ACRES

2.0 SUMMARY ENERGY PROFILE

2.1 Introduction

For a community its size, Beaver Creek has a wide range of building types and energy use patterns. According to the Territorial Government, the resident population of Beaver Creek is 90 persons. However, in assessing the energy demands in the profile of the community, it must be noted that during the months of May through September, the tourist traffic can increase the overnight population to as many as 500 people. This factor significantly affects the energy use in the community on a seasonal basis.

The energy demand profiles in this section summarize the fuel and electricity consumption patterns of the community by sector, and on an individual building basis.

Conservation priorities are identified in this section, and conservation opportunities are discussed in specific detail in Section 3.0. For further detail on the analyses and development of the energy profiles for individual buildings, the reader may refer to the Phase 1 Interim Report for this project.

2.2 Energy Demand Profile

In Beaver Creek, the energy which is used for heating buildings and generating electricity is supplied as fuel oil, propane, and wood. Fuel oil is used directly for space heating, hot water heating, or for generating electricity. Propane is used for cooking, laundry, and a limited amount of space heating. A small volume of wood is burned for space heating and hot water. Table 2-1 provides a breakdown of the fuel types consumed by each energy use sector in the community.

The community has been divided into the following sectors: Federal Government; Territorial and Municipal Governments; Commercial, including motel and lodges and the telephone and electric companies; and Residential, including Federal Government, Yukon Housing Corporation, private residential dwellings, and private residential dwellings which use only wood for heating.

The table shows the energy value in gigajoules of fuel input for each sector. The next three columns show litres of oil, litres of propane, and cords and cubic metres of wood.

TABLE 2-1

FUEL INPUT BY SECTOR AND TYPE

SECTOR	FUEL GJ		OIL litres		PROPANE litres	WOOD
FED GOVERNMENT	1,936	6%	51.421	6%		
YUKON & MUNICPL GOVT	2,275	7%	60,425	7%		
EDUCATION	619	2%	16.441	2%		
COMMERCIAL	8.432	25%	198,858	23%	35,000	
FED GOVT RESIDENTIAL	2,244	7%	59.602	7%		
YUKON HSG CORP	785	2%	20.850	2%		
RESIDENTIAL	1.920	6%	50.996	6%		
RESIDENTIAL (ttl wd)	774	2%			m3 cords	199 55
ELECTRIC GENERATION	15.205	44%	403.845	47%		
TOTAL	34.190		862.437			
TOTAL RESIDENTIAL	5.723	17%	131.448	15%		

Clearly, the predominant energy source in Beaver Creek is oil, with much smaller amounts of propane and wood used in some sectors.

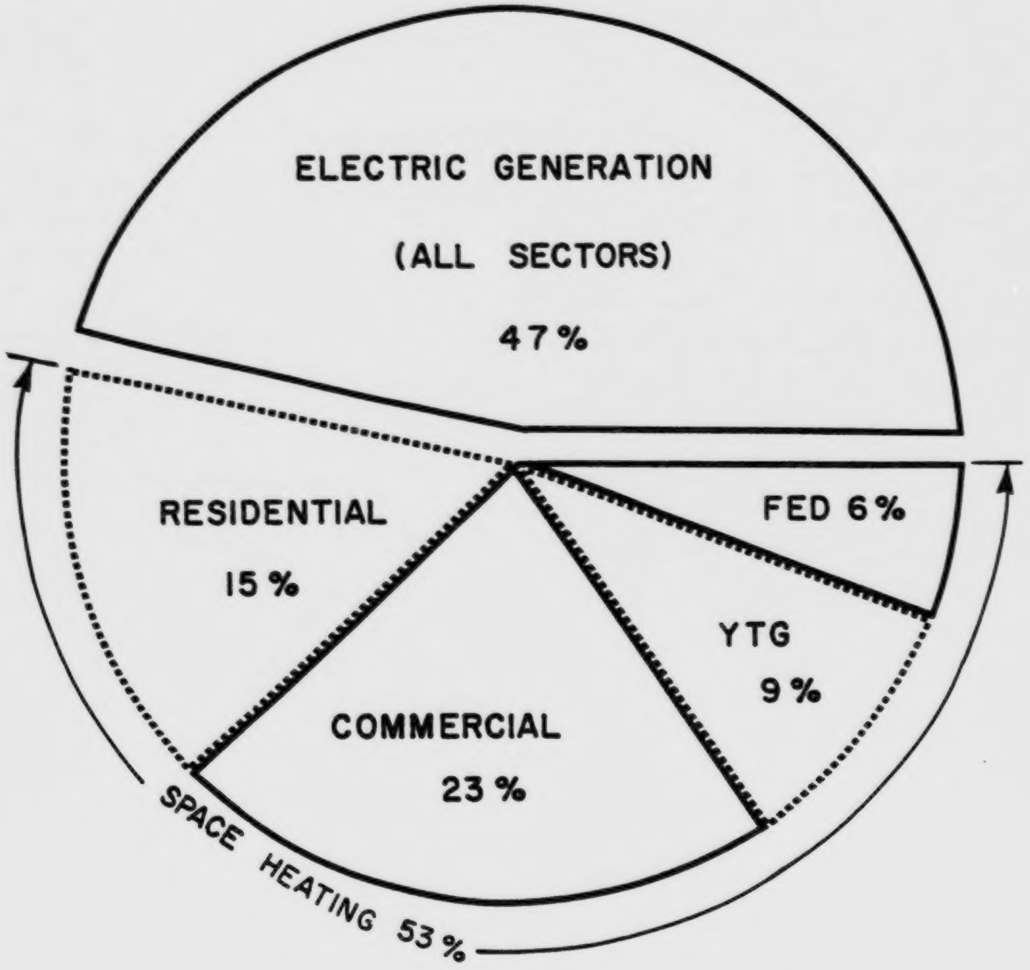
The following figure (Figure 2-1) illustrates the use of fuel oil by sector within the community (by percent). The lower segments in the plot show the relative use of oil for space heating among the four major user groups in the community.

The largest consumers of fuel oil for space heating are the commercial and residential sectors. However, electrical generation, at 47% of the total amount of oil consumed, represents by far the greatest single cause of oil consumption.

Electricity produced in Beaver Creek is used by all sectors. As well, some electricity is used to provide municipal services, such as street lights.

The relative percent of electricity used in each sector is shown in the following figure (Figure 2-2). Electricity used for municipal services is distributed among all user sectors.

The commercial sector, with 40% of the total electrical demand, is the largest user sector in the community, followed by the federal government residential sector at 15%. This was also the case for fuel oil, as shown in the previous figure. Because oil is used to heat most of the buildings and generate electricity, any opportunities for energy conservation in either the commercial or residential sectors will result in the greatest overall reduction of oil use in Beaver Creek.



ANNUAL TOTAL = 862,400 LITRES
32,500 GIGAJOULES

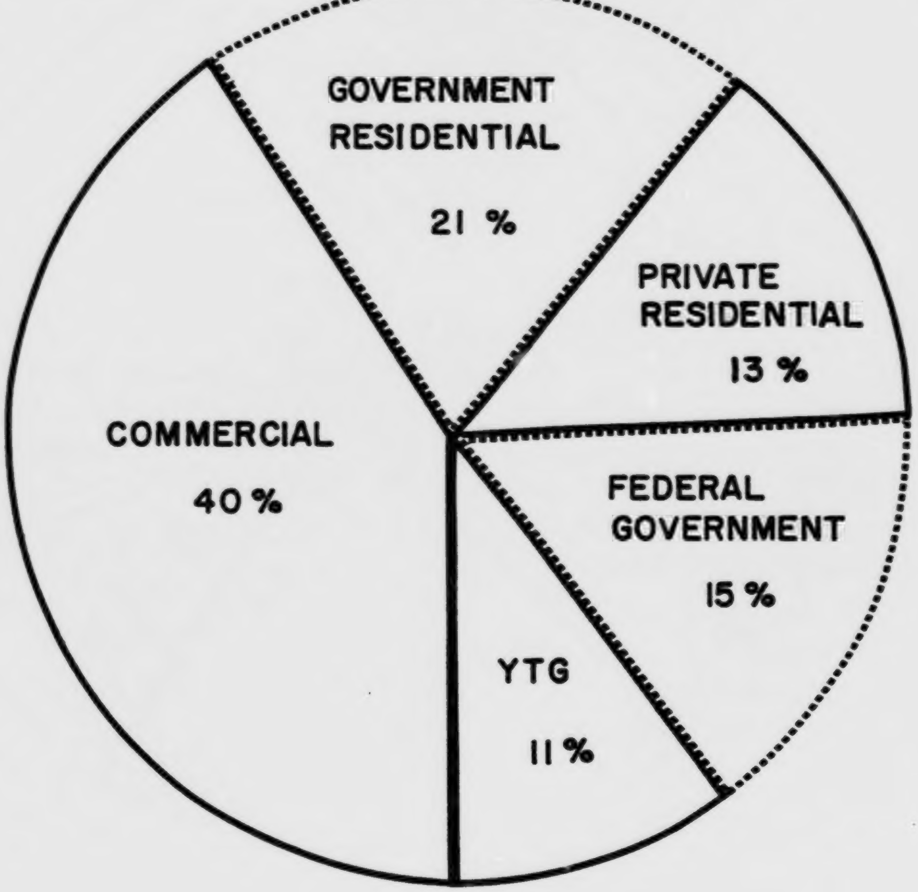
1984 VALUE = $210,200 HEATING FUEL
$186,500 ELECTRICITY GENERATION

FIG. 2-1

BEAVER CREEK

FUEL OIL USE BY SECTOR

ACRES



ANNUAL TOTAL = 1,224 MEGAWATT HOURS

1984 VALUE = $ 287,000

FIG. 2-2

BEAVER CREEK

ELECTRICITY USE BY SECTOR

ACRES

Table 2-2 shows energy use in the form of electricity and heating fuel compiled by sector. The total energy used (in gigajoules) for each sector is shown in the last column.

The remaining tables in this section provide an energy demand profile for individual buildings in each sector in Beaver Creek. These tables also show a "Retrofit Potential Index" for each building. This figure is used to identify the best candidates for energy conservation. The higher the Retrofit Potential Index, the greater the potential for reducing energy consumption through conservation.

In these tables, the first two columns identify the building. The next column shows the type of heating system identified by a numeric code as follows: (11) oil-fired forced air; (12) oil-fired hydronic; (23) propane-fired radiant; (33) electric radiant; (43) wood-fired radiant. If the building has a primary and secondary heating system, a four digit code is used. For example, (4311) is a wood-fired radiant heating system with oil-fired forced air back-up.

The next columns show measured heating system efficiency, building volume, and the heating load of the building. Heating load is separated into a Fuel Requirement, derived from consumption records, and a Net Heating Load, computed from the fuel requirement multiplied by seasonal furnace efficiency. Where actual furnace efficiencies were not available, a seasonal efficiency of 65% is used.

Average year fuel gigajoules are computed from the Fuel Requirement in megajoules per degree day (MJ/DDY)

COMMUNITY ENERGY PROFILE: BEAVER CREEK POPULATION: 90

TABLE 2 - 2
ENERGY USE BY SECTOR AND TYPE

SECTOR	# of BUILDINGS	%	ELECTRICITY MWH/BUILDING	TOTAL MWH	%	HEATING FUEL GJ/BLDG	TOTAL GJ	%	HTG & ELEC TOTAL GJ	%
FED GOVERNMENT	7	10%	26	183	15%	277	1.936	10%	2.596	11%
YUKON & MUNICPL GOVT	7	10%	16	114	9%	325	2.275	12%	2.685	11%
EDUCATION	1	1%	19	19	2%	619	619	3%	689	3%
COMMERCIAL	23	32%	21	488	40%	367	8.432	44%	10.188	44%
FED GOVT RESIDENTIAL	12	17%	16	189	15%	187	2.244	12%	2.924	13%
YUKON HSG CORP	5	7%	14	68	6%	157	785	4%	1.031	4%
RESIDENTIAL	10	14%	13	132	11%	192	1.920	10%	2.396	10%
RESIDENTIAL (ttl wd)	6	8%	5	29	2%	129	774	4%	878	4%
TOTAL	71			1.224			18.985		23.387	

TOTAL RESIDENTIAL 33 46% 419 34%

GJ USED PERCAPITA: 260

ELECTRIC GENERATION:kWh/litre gen eff: 3.03 15.205 GJ

TOTAL GJ INPUT: 34.190

GJ INPUT PERCAPITA: 380

multiplied by an average year degree days for Beaver Creek of 8838.

Where the data are available, a Performance Index is calculated for the building. This indicator is based upon the heating fuel requirements and the building volume and is a measure of the building's inefficiency. The larger the Performance Index, the more inefficiently the building is operating.

To enable a ranking of buildings for more detailed investigation a Retrofit Potential Index is calculated from the Performance Index and the average year gigajoules. By multiplying these two factors and scaling the result, it is possible to identify buildings with high energy requirements which are operating inefficiently. These buildings may have the greatest retrofit savings potential and therefore should be examined for economics.

This summary of energy demand by sector and for individual buildings in Beaver Creek provides the basis for identifying specific conservation opportunities which are addressed in the following Section.

TABLE 2 - 3

FEDERAL GOVERNMENT SECTOR

BEAVER CREEK BUILDING DATA: ENERGY DEMAND PROFILE EDPCAL1

IDENT	#	SECTOR	HTG SYS	EFF %	VOLUME m3	HEATING LOAD FUEL MJ/DDY	HEATING LOAD NET MJ/DDY	AVERAGE YEAR FUEL GJ	KJ FUEL /m3/DDY	RPI	TOTAL ELEC kWh/yr	DHW ELEC kWh/yr
3200	25	1	11	75	2391	143	93	1264	60	76	99651	1168
510	81	1	11	78	411	29	20	256	71	18	31322	694
140	111	1	11		127	15	10	133	118	16	4649	2000
215	135	1	11		422	22	14	194	52	10	4943	2957
340	112	1	12	82	460	9	6	80	20	2	5379	3614
330	30	1	11	74	114	1	1	9	9	0	1795	0
340	105	1	0		248	0					11827	2008
AVERAGE				77	596	31	21	277	47	17	22795	1777
TOTAL		7						1936			159564	12439

TABLE 2 - 4

TERRITORIAL & MUNICIPAL GOVERNMENT SECTOR

BEAVER CREEK BUILDING DATA: ENERGY DEMAND PROFILE EDPCAL2

IDENT	#	SECTOR	HTG SYS	EFF %	VOLUME m3	HEATING LOAD FUEL MJ/DDY	HEATING LOAD NET MJ/DDY	AVERAGE YEAR FUEL GJ	KJ FUEL /m3/DDY	RPI	TOTAL ELEC kWh/yr	DHW ELEC kWh/yr
350	123	2	11	79	1643	121	83	1069	74	79	36714	1789
145	101	2	11		1207	53	34	468	44	21	12419	1825
245	150	2	2333		23	7	6	63	319	20	8820	0
400	69	2	11	71	424	28	17	247	66	16	5666	657
2975	23	2	11		332	20	13	177	60	11	17906	
380	103	2	33		194		28	38	143	5	10281	183
130	109	2	12		882			209			7271	
AVERAGE				75	672	46	26	325	101	22	14154	636
TOTAL		7						2272			99078	4454
140	75	3	11	67	1656	70	40	619	42	26	16921	2117

TABLE 2 - 5

COMMERCIAL SECTOR

BEAVER CREEK BUILDING DATA: ENERGY DEMAND PROFILE EDPCAL4

IDENT	#	SECTOR	HTG SYS	EFF %	VOLUME m3	HEATING LOAD FUEL MJ/DDY	HEATING LOAD NET MJ/DDY	AVERAGE YEAR FUEL GJ	KJ FUEL /m3/DDY	RPI	TOTAL ELEC kWh/yr	DHW ELEC kWh/yr
470	59	4	11	69	824	125	74	1105	152	168	88785	
660	55	4	12	73	1522	137	86	1211	90	109	40130	0
710	53	4	12	71	380	38	23	336	100	34	17139	
445	61	4	11	80	429	39	27	345	91	31		
45	8	4	11	77	436	21	14	186	48	9	26202	5293
300	107	4	11	76	166	12	8	106	72	8	56746	
475	117	4	12	81	1840	88	62	778	5	4	142225	
535	114	4	12		3311							
510	119	4	12		3619							
470	111	4	12		3585							
490	123	4	12	81	1081			2949	oil DHW			
490	115	4	12		961							
510	127	4	12		328						1660	
485	125	4	12		77						381	
525	130	4	12		539						20066	
550	128	4	12		1416						6552	
510	109	4	21		79							
480	122	4	12		69							
430	65	4	43		72	0					61	
485	143	4	43		191	0	0	0	0	0	608	0
660	61	4	33		65		3	337	oil DHW		11189	3577
445	63	4	33		100						12637	
435	61	4	33		86			135	oil DHW			
AVERAGE				76	921	51	13	340	29	16	18451	386
TOTAL		23						7487			424381	8870

TABLE 2 - 6

FEDERAL GOVERNMENT RESIDENTIAL SECTOR

BEAVER CREEK BUILDING DATA: ENERGY DEMAND PROFILE EDPCAL5

IDENT	#	SECTOR	HTG SYS	EFF %	VOLUME m3	HEATING LOAD FUEL MJ/DDY	HEATING LOAD NET MJ/DDY	AVERAGE YEAR FUEL GJ	KJ FUEL /m3/DDY	RPI	TOTAL ELEC kWh/yr	DHW ELEC kWh/yr
360	79	5	11		254	27	18	239	106	25	13961	4782
365	77	5	11		254	27	18	239	106	25	7967	
345	89	5	11	74	473	27	17	239	57	14	11089	2336
350	85	5	11		473	27	18	239	57	14	17463	3030
355	83	5	11	70	422	24	14	212	57	12	16063	2884
585	32	5	11	82	323	20	14	177	62	11	24920	5366
540	34	5	11		286	17	11	150	59	9	15635	3687
360	41	5	11	76	544	23	15	203	42	9	15043	4015
220	83	5	11		529	20	13	177	38	7	10530	3322
220	75	5	11		529	20	13	177	38	7	15162	2482
250	87	5	11		529	16	10	141	30	4	11015	6278
330	34	5	11		183			50	may-sep		5867	3322
AVERAGE				76	400	23	13	187	59	11	13726	3458
TOTAL		12						2242			164715	41501

TABLE 2 - 7

YUKON HOUSING RESIDENTIAL SECTOR

BEAVER CREEK BUILDING DATA: ENERGY DEMAND PROFILE EDPCAL6

SECTOR					VOLUME	HEATING LOAD		AVERAGE	KJ FUEL	RPI	TOTAL	DHW
			HTG	EFF	m3	FUEL	NET	YEAR	/m3/DDY		ELEC	ELEC
IDENT	#		SYS	%		MJ/DDY		FUEL GJ			kWh/yr	kWh/yr
275	139	6	11	74	422	23	15	203	53	11	6489	3504
230	141	6	11	80	422	17	12	150	40	6	11901	3504
250	130	6	11	80	422	17	12	150	40	6	7620	3504
245	144	6	11	78	422	16	11	141	38	5	6717	3504
265	134	6	11	82	422	16	12	141	38	5	4916	3504
AVERAGE				79	422	18	12	157	42	7	7529	3504
TOTAL		5						787			37643	17520

TABLE 2 - 8

PRIVATE RESIDENTIAL SECTOR

BEAVER CREEK BUILDING DATA: ENERGY DEMAND PROFILE EDPCAL7

SECTOR					VOLUME	HEATING LOAD		AVERAGE	KJ FUEL	RPI	TOTAL	DHW
			HTG	EFF	m3	FUEL	NET	YEAR	/m3/DDY		ELEC	ELEC
IDENT	#		SYS	%		MJ/DDY		FUEL GJ			kWh/yr	kWh/yr
670	61	7	11		230	20	13	177	87	15	15825	5037
1540	27	7	11		458	28	18	247	61	15	8316	2884
430	34	7	11		169	16	10	141	95	13	11354	4015
640	60	7	11		157	15	10	133	96	13	10833	3322
1513	27	7	1143	81	494	25	18	221	51	11	12736	4125
275	101	7	11	76	449	23	15	203	51	10	7311	2920
440	28	7	11	78	578	26	18	230	45	10	11540	2592
740	38	8	4212	76	649	27	18	236	41	10	20405	1132
255	101	7	11	76	449	21	14	186	47	9	5841	2811
520	67	7	1243	63	558	16	8	141	29	4	11070	949
AVERAGE				75	419	22	14	192	60	11	11523	2978
TOTAL		10						1915			115231	29784
400	35	8	4311		154	17	11	150	110	17	8760	5585
610	38	8	4311		254	19	13	170	76	13	3074	3614
580	138	8	43		202	17	11	150	84	13	8609	5256
95	195	8	43		165	14	9	124	85	11	2605	
555	160	8	43		173	13	6	112	73	8	1793	
860	34	8	43		107	8	5	70	74	5	445	
AVERAGE					176	15	9	129	84	11	4214	2409
TOTAL		6						776			25285	14454

3.0 PRINCIPAL CONSERVATION MEASURES

Principal conservation measures for the buildings in Beaver Creek include air-leak sealing, adding insulation, retrofit and upgrading of the space heating and domestic hot water systems, including tuning & servicing, and implementing energy management practices. The following subsections provide analysis of the impact that these measures can have in Beaver Creek

3.1 Air Sealing and Insulation

Nearly all of the buildings in Beaver Creek were constructed without continuous air-vapour barriers, nor do they have insulation levels appropriate for the climate.

For most buildings, the best means for reducing the space heating energy requirements involves sealing air leaks in the building envelope.

Typical areas of air leakage are: at the sill plate between the walls and foundation; where plumbing stacks, chimneys, and electrical wiring penetrate the ceiling; through wall plugs and switches; at the electric service entry panel; at the top plate of interior partitions; and around windows and doors, including the attic hatch.

The next major reduction in energy requirements can be achieved by insulating areas of a building envelope which presently have no insulation, such as exposed concrete foundation walls or exposed floors.

The common practice of adding insulation in the attic may not be the most cost-effective energy conservation measure.

In fact, it can increase moisture damage if thorough air-sealing in the attic is not done before installing additional insulation.

Damage occurs when moisture (carried up into the attic with the warm interior air) condenses in the attic insulation. This moisture can be responsible for structural deterioration through rot, especially when additional insulation inhibits the escape of moisture during the warmer seasons.

In most cases, there is a significant amount of air leakage through the ceiling, and air-sealing alone will stop more heat loss than extra insulation.

If the building has 8.9 cm (3.5") of insulation (or less) in the walls, then the application of a full air-vapour barrier wrap and adding a minimum of twice as much insulation, may be the most cost-effective means of bringing the building to current energy conserving standards.

3.2 DHW Conservation

Domestic Hot Water (DHW) conservation opportunities include lowering the hot water temperature, installing low-flow showerheads, and insulating the water tank and the water pipes.

Reducing the water temperature by adjusting the thermostats on the tank is a no-cost conservation option which will result in immediate savings. Building operators may find that there is less hot water available, once the temperature setting is reduced. If this occurs, then further conservation measures can be implemented to reduce the demand for hot water at the tap.

A range of water saving or "low-flow" devices are available for showers and faucets. The cost for a water saver device starts at ten cents for a simple yet effective design.

The hot water tank and the pipes which carry hot water from the tank to the tap lose a considerable amount of heat. Particularly with electric hot water tanks, this is an expensive way to provide space heating.

Although most tanks are insulated with a layer of fibreglass at the factory, additional insulation can be installed to further reduce the loss from the tank. Pre-fabricated hot water tank "blankets" for standard tank sizes are usually available in Whitehorse at a reasonable cost. Many building operators choose to do the job themselves. All that is required is to wrap the entire tank with a layer of fibreglass and a polyethylene cover, and secure it with duct tape.

There are several types of pipe insulation available at most building supply stores. Otherwise these can be ordered through retail outlets in Whitehorse.

3.3 Furnace Efficiency

Furnace efficiency testing should be part of a regular annual servicing of oil-fired heating systems. The furnace testing equipment commonly used measures "steady state" efficiency. This efficiency is measured with the furnace at normal operating temperature. Over the course of a heating season, this value usually decreases by about 10% due to several factors, including reduced efficiency when the furnace starts up, and the "stack effect" created in the chimney, which cools the heat exchanger inside the furnace when the burner is off. This reduced efficiency is known as "seasonal" efficiency.

The furnace fan turns on to blow air through the distribution system when the heat exchanger reaches a specific temperature. The fan turns off when the temperature drops to a certain point. Furnace fan settings can often be lowered several degrees to make better use of the heat available at the heat exchanger.

Reducing the size of the nozzle on the furnace can reduce energy consumption as well. Many oil furnaces are suitable for this modification, however, it should only be performed by a qualified furnace servicing expert.

A more costly, but effective device for reducing energy waste through the furnace flue is the automatic stack damper. When the furnace is not operating, an automatic stack damper will block the flue pipe, thus preventing warm air from escaping up the chimney through the barometric damper or through the combustion chamber of the furnace. It automatically opens before the furnace burner turns on. Safety features prevent the furnace burner from igniting until the stack damper is open. The effect of these units is to raise the seasonal efficiency to a value closer to the steady state efficiency.

Retention head burners increase the combustion efficiency of the fuel-air mixture. The retention head is shaped to provide a turbulent flow of combustion air to mix with the fuel. In this well mixed state, the fuel burns more completely, squeezing more useable heat out of each litre. They can generally increase steady state efficiency by ten percent.

With good tuning practices, seasonal oil furnace efficiency can usually achieve 75%. Many of the oil heating systems which were tested during the audits in Beaver Creek showed a seasonal efficiency of less than 70%.

With some furnaces, it is possible to achieve 80-85% seasonal efficiency with the combination of a stack damper and a retention head burner.

All oil-fired heating systems in Beaver Creek should be tested and adjusted to their maximum potential efficiency. Additional upgrading of nearly all furnace systems is economically feasible.

3.4 Operating Practices and Energy Management Techniques

The measures described above account for many of the factors which affect energy consumption. However, operating practices, such as temperature setting, hot water use, and electricity use, also contribute to energy consumption.

The efficiency of operating practices plays an increasingly more significant role in building energy performance as the building itself becomes more efficient through conservation. Building owners and operators in Beaver Creek could benefit from training in occupant-related energy conservation techniques, which they may wish to apply to maximize energy savings.

Typical energy management options for reducing energy consumption include: lowering indoor temperatures (especially when the building is unoccupied and at night), using hot water only when necessary, keeping windows and doors closed during the heating season, and ensuring regular maintenance and servicing of the heating and ventilation system.

3.5 Training and Use of Local Resources

In nearly all cases, the economic justification for implementing conservation is increased if the work is done by local people. In many cases, especially in communities like Beaver Creek, some of the options may be uneconomic if outside contractors are used. Therefore, the training of local people to do retrofit work is extremely important. In addition, this method will create local employment, and keep more dollars in the community.

Many of the conservation and alternative energy developments proposed in this study are relatively simple undertakings and the costs are quite small. However, if contractors from Whitehorse or elsewhere are called in to perform these tasks, the mobilization costs alone could amount to several times the cost of actually doing the work. It is essential that every effort should be made to perform the work locally.

3.6 Projected Energy Conservation Impact

In the course of this study, specific measures for reducing energy consumption through conservation were developed for every building in Beaver Creek. Details of the methodology and actual analyses for all buildings are included in the Phase I - Interim Report for the Beaver Creek Energy Planning Study.

Conservation opportunities were divided into those reducing DHW energy consumption and those reducing space heating consumption. In most cases, the DHW savings result in reductions of diesel electric generation while the space heat items lead to reduced fuel oil purchases.

For each building in the community, where an energy consumption profile could be formulated, a conservation analysis was performed. Data for a sample building conservation analysis is provided in Table 3-1. In the upper portion of the table, DHW conservation opportunities are examined. Before and after conservation electric consumption is calculated and the resulting annual savings in kWh and dollars is provided. Below these items, the possible conservation measures are listed along with the estimated costs of these projects.

The same pattern of information with respect to space heating is found in the lower portion of the table. Before and after conservation heat loads and costs are tabulated with the conservation measures and costs detailed at the bottom.

In Table 3-2, the economic attractiveness of the suggested conservation measures is assessed. Taking the cost of conservation measures and the annual savings expected, the payback period, net present value and benefit/cost ratio are calculated for each investment.

TABLE 3 - 1 SAMPLE, ENERGY CONSERVATION ANALYSIS

BUILDING

VOLUME (cubic metres)	473			
			rate	$.27/kWh
	sep-apr	apr-sep	annual	value
ELECTRICITY USE (kWh pr day)	41	18	11170	$3016
	present	with	annual savings	
DOMESTIC HOT WATER (kWh/day)	6	6	329	$89

labor rate $20/hr

CONSERVATION OPTIONS	material	labor hrs	cost estimate
reduce temperature to 120 F, and		.25	$5
install low flow showerhead	$10	.25	$15

SPACE HEATING	present	with	annual savings
HEATING ENERGY DEMAND (MJ/DDY)	27	14	
AVERAGE YEAR FUEL INPUT (Gigajoules)	239	124	115
(litres)	5759	3565	2193
AVERAGE ANNUAL COST (@ $0.46/litre)	$2649	$1640	$1009
PERFORMANCE INDEX (kJ/m3/DDY)	57	30	
RETROFIT POTENTIAL INDEX	14	4	
SEASONAL FURNACE EFFICIENCY (%)	65	70	
THERMAL LOAD (MJ/DDY)	18	10	
(GJ/YEAR)	155	87	

labor rate $20/hr

CONSERVATION OPTIONS	material	labor hrs	cost estimate
air seal doors, windows, attic, and	$150	16	$470
upgrade attic insulation to R40, and	$500	8	$660
install stack damper, and	$300	1	$320
install ducted return air to ceiling, and	$200	8	$360
service and balance heating system, and	$100	2	$140
replace or upgrade windows	$2000	120	$4400

The building requires remedial work on an incomplete furnace retrofit: when unit was upgraded to forced air, no provision was made for ducted return air from second level ceiling.
Conservation costs based on trained, available, local labor; materials cost F.O.B. Whitehorse
Present energy consumption derived from 1983-84 data

TABLE 3 - 2

ECONOMIC ASSESSMENT OF CONSERVATION MEASURES

BUILDING: SAMPLE
(Ident.)

	DOMESTIC HOT WATER	SPACE HEATING
PRESENT CONSUMPTION:	1000 kWh $270.00	6000 litres $2760.00
CONSERVATION EFFECTS:		
Initial Cost	$100.00	$1000.00
Annual Energy Savings	100 kWh	500 litres
Annual Dollar Savings	$27.00	$230.00
Investment Payback (years)	3.7	4.3
Net Present Value of Conservation Measures:		
@ 5% discount rate	$180.25	$1387.32
@ 10% discount rate	$105.36	$749.40
@ 15% discount rate	$57.88	$344.90
@ 10% discount rate and 2% escalation in energy prices	$128.76	$948.70
Benefit/Cost Ratios:		
@ 5% discount rate	2.8	2.4
@ 10% discount rate	2.1	1.7
@ 15% discount rate	1.6	1.3
CONSERVATION MEASURES RECOMMENDED:	YES	YES
ADJUSTED ENERGY CONSUMPTION AFTER RECOMMENDED MEASURES:	900 kWh	5500 litres

COMMUNITY ENERGY PROFILE: BEAVER CREEK POPULATION: 90

TABLE 3-3

ENERGY USE BY SECTOR AND TYPE WITH CONSERVATION MEASURES

			ELECTRICITY			HEATING FUEL			HTG & ELEC	
SECTOR	# of BUILDINGS	%	MWH/BUILDING	TOTAL MWH	%	GJ/BLDG	TOTAL GJ	%	TOTAL GJ	%
FED GOVERNMENT	7	10%	26	173	15%	182	1,277	10%	1,900	11%
YUKON & MUNICPL GOVT	7	10%	16	111	9%	180	1,259	10%	1,658	10%
EDUCATION	1	1%	18	18	2%	374	374	3%	440	3%
COMMERCIAL	23	32%	21	484	41%	236	5,424	42%	7,165	42%
FED GOVT RESIDENTIAL	12	17%	16	176	15%	144	1,725	13%	2,358	14%
YUKON HSG CORP	5	7%	12	62	5%	127	636	5%	861	5%
RESIDENTIAL	10	14%	12	120	10%	147	1,465	11%	1,898	11%
RESIDENTIAL (ttl wd)	6	8%	5	29	2%	120	720	6%	824	5%
TOTAL	71			1,174			12,880		17,103	
TOTAL RESIDENTIAL	33	46%		388	33%	GJ USED PERCAPITA:			190	
ELECTRIC GENERATION:kWh/litre gen eff:			3.03	14,589	GJ	TOTAL GJ INPUT:			27,469	
						GJ INPUT PERCAPITA:			305	

Projects which have a payback of less than 5 years and a benefit/cost ratio of at least 1.1 are confirmed as recommended.

Taking all buildings in Beaver Creek together, total expenditures of $117,400 are recommended for conservation projects. If all of these recommended projects are undertaken, the annual dollar savings estimated for the community as a whole would amount to $76,000. Table 3-3 presents the energy use by sector and type for the post-conservation scenario. This table should be compared with Table 2-2 in the previous section which represents the before-conservation case.

In comparing the post-conservation energy use by sector and type with the present energy consumption for Beaver Creek, as shown in Table 2-2, it can be seen that the greatest change would occur in heating fuel, where the post conservation total gigajoules for heating fuel is 68% of the present heating fuel use.

The greatest change occurs in the municipal and Yukon government sector, where post-conservation energy use for heating fuel would be only 55% of present energy use. In this sector, significant conservation savings occur as a result of a major retrofit to the grader station, and extensive air-leak sealing and selected insulation upgrading on all municipal and Yukon government buildings. The second largest change occurs in the commercial sector, where only 64% of the present energy used would be required after conservation. The major savings occur due to reductions in fuel used to supply domestic hot water in tourist accommodation facilities.

Post-conservation electrical consumption in the community would be 96% of the present use, entirely as a result of DHW conservation. In summary, it can be seen that the annual gigajoule input per capita would be reduced from 380 gigajoules to 305 gigajoules after conservation.

4.0 ENERGY RESOURCE AND SUPPLY ALTERNATIVES

4.1 Introduction

Alternative energy sources for remote northern communities can range from simple, "soft" technologies such as greenhouses which provide energy to single residence, to capital intensive hydroelectric facilities that could supply all of the energy needs for an entire community. The following list indicates some of the options which may be appropriate for reducing dependence on oil:

- biogas
- hydroelectric
- coal
- wind
- grid extensions
- waste oil recovery
- waste heat recovery
- wood
- solar power
- peat
- geothermal

The technology for utilizing all of these resources is for the most part proven and available. However, before a particular alternative can be recommended for a community, a number of factors, in addition to technical feasibility, must be addressed. Some of these include availability of supply, pattern of demand, system capital and operating costs, reliability of system and resource supply, personal perceptions of comfort, institutional environment, etc.

In the following sub-sections, the analysis of several alternatives for Beaver Creek is presented. Detailed assessments for all possible energy supply technologies are not provided, on the grounds that they simply do not merit consideration beyond a cursory level. The assessment of alternatives presented here adheres to the procedures outlined in the Energy Planning Handbook. The steps prescribed involve an elimination process whereby unpromising alternatives are discarded early, as soon as the basic criteria for them are found to be lacking. This report reflects a similar process.

The discussion and analysis which follows, begins with those options considered to show the greatest potential for feasibility in Beaver Creek. Other alternatives which were examined but rejected, are treated more briefly at the end of this section. In the case of the latter, the key reasons for rejecting the technology are presented.

In the analysis of energy alternatives, the assumed energy load is that which would persist after the implementation of all recommended conservation measures. Invariably, the economic returns attributed to conservation exceed the advantages of any alternative energy systems and should be implemented first. In addition, if alternatives had to be sized and designed to satisfy grossly inefficient consumption patterns, the difficult task of justifying the alternative will, in many cases, be compounded.

4.2 Wood Fuel

The area surrounding Beaver Creek is not densely forested and further detailed study is required to establish the availability of a substantial, sustainable fuel supply. The stands of timber in the region have been designated for saw log utilization and even these resources are considered limited. There are some fire killed stands and other potential fuel wood areas in the Beaver Creek region, but vehicle access to these is, in many cases, difficult. The Forest Service does not incorporate poplar stands in its forest inventories because the species has no commercial wood product potential. However, it has been noted that significant stands of poplar occur along the Alcan Highway in the Beaver Creek area. These trees are growing in areas cleared during highway construction over 40 years ago and have attained heights of 12 metres (45 feet) with diameters of about 20 centimetres (8 inches). Access to these areas would be easy in the winter and a significant fuel supply could be harvested. A detailed inventory of this resource should be conducted.

Given the scale of operations and demand necessary to justify electrical generation, this utilization cannot be considered viable in Beaver Creek. Gasification or steam technologies necessary for electic generation tend to involve significant capital costs and/or tend to be relatively complicated and unreliable for remote community operation. In addition, such systems would need the equivalent of up to 1500 cords of wood fuel per year to develop the amount of electric energy required. Typically the conversion efficiences of wood to electricty generation systems are exceedingly low (i.e., 15 percent to 20 percent). It is unlikely it would be economic to install the necessary equipment in Beaver Creek to supply only about 1000 MWh of power.

Direct heating of space and water would be more practical uses of wood fuel in Beaver Creek. This does not have to be on a large-scale, community-wide basis, and therefore the application can be more suitably tailored to the local wood fuel supply. The simplest approach to wood combustion for space heating would involve the collection and use of round wood, in fireplaces and wood stoves, by individual building owners or operators. This has already been done by many individuals in Beaver Creek who pay for their heating fuel. There appears to be a sufficient wood supply in the Beaver Creek area for either collective or individual harvesting to supply at least the residential sector with substantial space heating energy. (Quite a lot of slash debris and other discarded waste wood is observable around the community). The only capital outlays involved would be for the installation of wood burning stoves in those residences which do not presently have one. These cost on the order of $1,500 each.

Despite the somewhat lower combustion efficiencies typically obtained with wood burners, wood fuel is competitive with oil furnace space heating if the cost of fuel oil is about 45¢/litre and the cost of the wood is less than about $90.00 per cord. On a delivered energy basis, air tight wood stoves can supply space heat for about 50 percent of the cost of an oil furnace. However, it is recognized that wood is less convenient to use than oil and that many residents of Beaver Creek have little incentive to substitute wood for oil. With appropriate incentives however, many more cords of wood could be utilized in Beaver Creek.

There are presently 28 residential buildings in Beaver Creek where little or no wood burning is being done. This includes the presently unoccupied YHC dwellings. Most of these buildings are owned by the federal or territorial governments and rely almost exclusively on oil-furnaces for space heating. On average, each of these requires 100 GJ of net energy (i.e., after combustion losses) for space heating.

Reasonably efficient wood stoves will average about 50 percent seasonal efficiency and therefore yield about 8 GJ of net energy per cord of wood. This would result in a requirement for 12.5 cords per year to heat each house. Assuming a fuel cost of $100 per cord, this amounts to $1,250 per year. The oil displaced would be about 4,250 litres per building which would have a 1984 value of $1,960. Therefore, the annual savings would amount to $710. At this rate, the payback on the installation of the wood stove would be 2.1 years.

The net present value of the investment at a real discount rate of 5 percent and an expected life of 10 years would be $3,982. In other words, if an individual had a choice between wood heating or investing the same amount of money in a bank term deposit paying 5% more than the rate of inflation, he would be close to $4,000 wealthier if he took the wood stove investment. Wood burning is clearly economically attractive for these buildings. Some of the commercial buildings in Beaver Creek could also benefit from wood utilization for space heating. In fact, as a result of the energy survey, Ida's Motel converted some of their heating to wood.

One additional use of wood which has been suggested for Beaver Creek involves the firing of a wood fuel boiler in conjunction with a diesel waste heat recovery district heating system. The bulk of the heating system's energy would be supplied by waste heat from the diesel but the wood fuel would supplement this during peak demand periods. Since the total demand for wood in such a situation would not be very large, it would be expected that sufficient wood from the surrounding area would be available. However, it still would be necessary to either contract for, or organize on a community basis, a collection, preparation and stockpiling program. If it is assumed that a district heating distribution system is already in place, connection of a wood fired boiler to the system does not involve any specialized technology or difficult mechanical arrangements. For this type of application, a chipper should be utilized since chipped fuel is easier to handle and burns more efficiently in a boiler.

The key concern will be whether the energy supplied by the additional boiler would be sufficient to justify its cost, maintenance and operation. Without an anlysis of hourly electric generation records and hourly space heat demand records, it is not possible to specify exactly what the total volume of energy in peak periods not met by the diesel waste heat recovery system would amount to. However, as noted in Section 4.4, the diesel waste heat will exceed the heating demands of buildings which can be economically connected to the district heating grid most of the time. Therefore, it is possible that a wood-fired boiler would be supplying only a very small increment of energy and would be operating less than 10 percent of the time.

Figure 4-1 illustrates the type of analysis required to determine the economic viability of using a wood fired boiler, or any other supplementary heat source, to handle peaks on a central heating grid. In the figure, the dark curve indicates a typical demand function based on time.

To construct this curve for Beaver Creek, hourly heat demand records would be required. Assume that the supply system capacity indicated by Case 1 in the figure represents the amount available from the primary heat source, which of course should be the least expensive source. The amount of unsatisfied demand would be the area under the curve above the Case 1 dotted line and would generally represent some small portion of the total time. The annual utilization of the system, and therefore the efficiency is quite high however, since most of the Case 1 energy is used. The surplus is indicated by the hatched area.

If a larger system (Case 2, Figure 4-1) is designed to supply the peaks, the system cost can go up much faster than the additional energy provided. It is generally not efficient, from an economic standpoint, to design systems to meet extreme peaks. In the case of a central heating system for example, pipe sizes, pump sizes, boilers and storage tanks all would have to be upgraded, perhaps as much as doubled, to meet the peaks. However, the additional energy supplied could be less than 10 percent. Clearly the unit costs of such a system would preclude economic feasibility. Based on this rationale, it is not expected that wood fuel or other supply supplements will be appropriate for a central heating system. Detailed study of demand records would be necessary to determine the economics of any given option however.

Given the foregoing, the best use of wood in Beaver Creek is likely to be for use in wood stoves for individual building space heating. Given the appropriate incentives, the total consumption of wood in Beaver Creek could be expanded. At the present time, only about one-fifth of

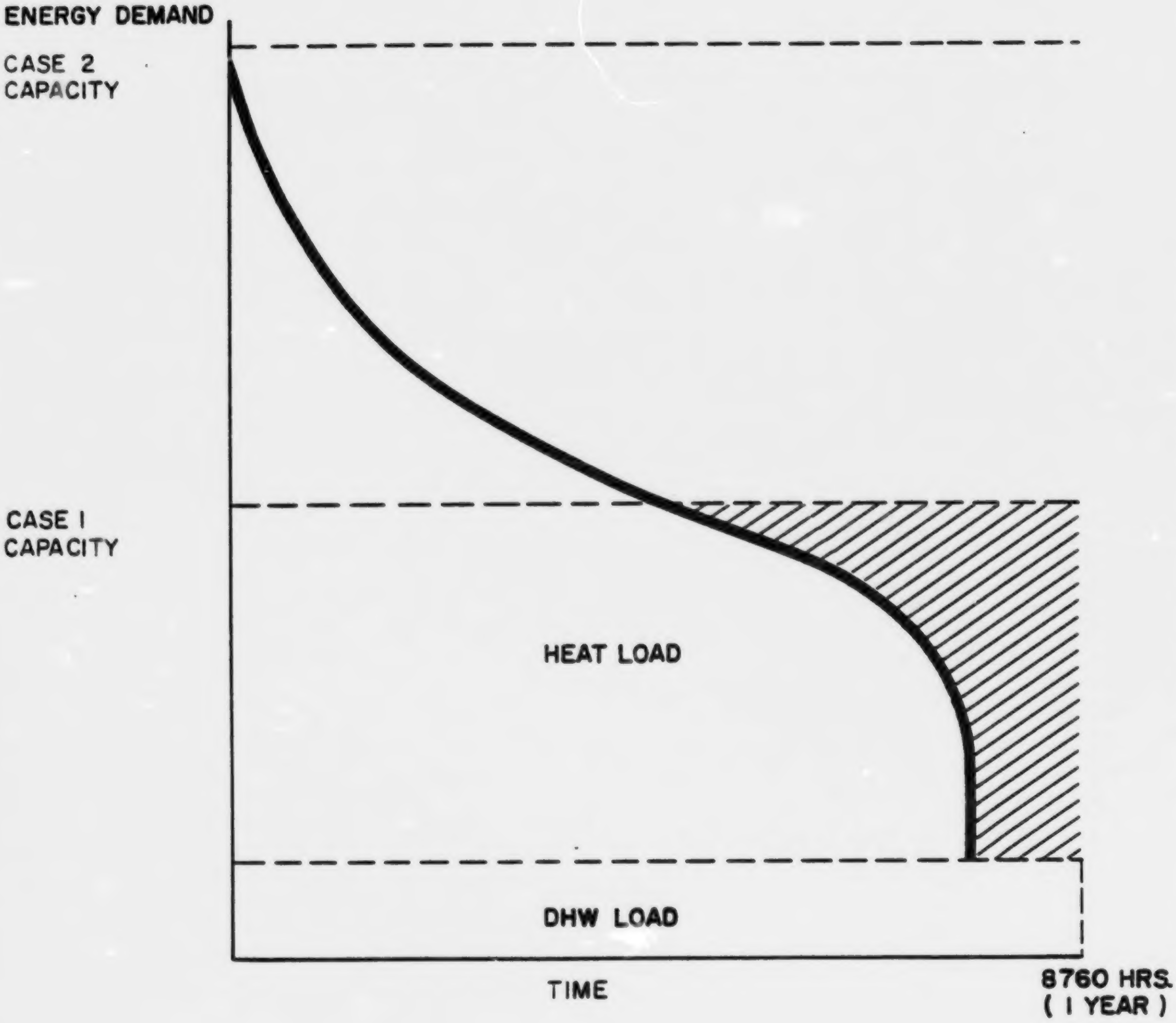


FIG. 4-1

ENERGY SYSTEM
CAPACITY OPTIMIZATION

ACRES

the residences in the community rely on wood for a substantial portion of their space heating needs. However, there is sufficient wood supply in the area, such that virtually all residential buildings could convert to wood as the primary source of space heat energy.

4.3 Waste Oil Recovery

There are three significant sources of waste oil in Beaver Creek. The largest of these is the Government of Yukon highways garage with the bulk of the remainder made up by the crank case oils from the YECL diesel generators and lube and crank case oils from the truck maintenance facilities at the Far West garage. The highways equipment currently utilizes close to 10,000 litres of lubicating oils annually. It is estimated that with proper care and a well managed collection system, approximately 70 percent of this volume can be recovered and potentially used by a space heating furnace. In addition, monthly oil changes on the diesel generators could provides about 1,150 litres/year also assuming a 70 percent recovery rate. Data on the volume of recovered oil that might be collected at Far West was not available for this study. It would be expected however that the order of magnitude volume would be similar to that produced by the diesel generators. Approximately 9,000 litres of usable waste oil might be available in Beaver Creek annually.

Waste oil can be burned in specially designed furnaces. Since the highways garage is the largest source of waste oil in Beaver Creek, and also represents a large space heating load even with conservation, this would be the logical facility for utilizing waste oil. All that would be required at the highways complex would be a waste oil recepticle and storage container and waste oil furnace.

Oil wastes generated at Far West and the electric plant could be delivered to the highways facilities in 45 gallon barrels or other suitably small containers that are easily handled. There should also be a recepticle at highways yard for others to dispose of their waste oils since individual vehicle owners, the forestry department, the RCMP and others will also have waste oil to dispose.

A 5,000 litre storage tank would be appropriate for the highways garage. With this volume of storage, waste oils collected during the summer months, when heat loads are relatively low, can be retained for winter use. During the winter, consumption of the waste oils will exceed the rate at which new waste oil is deposited. The cost of a 5,000 litre storage tank would be approximately $3,500 delivered in Beaver Creek. The tank should also be fitted with proper venting, a water removal valve, and a funnel shaped inlet containing a filter to remove sediments and metallic particles from the waste oil. Generally commercially available waste oil burners require that the fuel injected into the combustion chamber be near room temperature. Therefore, it is suggested that the storage tank or a smaller day tank be placed within the highways garage if possible.

In the energy survey portion of the study, it was determined that the Government of Yukon highways facility presently consumes 28,500 litres of fuel oil for space heating purposes. Conservation measures were subsequently identified which could reduce this amount by 18,474 litres. While a majority of these savings (60%) would result from substantial air leak sealing and furnace upgrading, about 40 percent of this savings amount, or 7,390 litres, would have been achieved through significant insulation retrofits to the ceiling, walls, windows and doors of the building. This full wrap retrofit is estimated to have a capital cost of about $46,000. The economic payback on the insulation retrofit was found to be questionable. Assuming the insulation retrofit is not undertaken, the net fuel oil requirement for the highways facility would be on the order of 17,400 litres annually. Waste oil could provide on the order of 52 percent of this space heating requirement. The 1984 value of the system in terms of fuel oil purchases which would be displaced would thus be about $4,000 per year.

Utilization of the waste oil would involve an additional capital outlay for a furnace specifically designed to burn both waste and conventional heating oil. There are several manufacturers currently supplying such units and it is estimated that the cost for a furnace appropriate to the highways garage, with about 350,000 btus per hour capacity, would be about $7,500 installed.

Further investigation would be required into the actual specifications and operating characteristics of waste oil burners. A pilot project initiated in British Columbia by the Ministry of Transportation and Highways ran into difficulties when the Lanair furnace which was installed failed to obtain CSA certification. The problem arose from the daily need to manually remove, clean and replace the vaporizing pan of the heater. When this was done, the furnace had to completely cool by the time fuel was re-introduced. Otherwise, an explosion hazard could result. It was not possible in this study to determine if this problem was common to all waste oil burners. Certainly, waste oil burners have received acceptance and safety authority certification in the United States and Europe and it would be expected that an appropriate unit could be identified for use in Beaver Creek.

In the context of waste oil utilization, the Highways Garage would be the most logical building. However, as discussed in the next subsection, a district heating system utilizing waste heat from the diesel generators could also be a feasible alternative for the Highways facility. The district heat plan involves substantial capital cost and the connection of many more buildings in the community. Thus, it can be expected that implementation of this scheme will be much more complex.

Judgement will have to be exercised as to the likelihood of the heat recovery plan going ahead before a commitment is made on the waste oil installation. If it appears that the district heating will be installed in the near future, consideration should be given to utilizing waste oil in buildings which would not be on the heat distribution grid. Appropriate candidates might be Ida's, Far West and the Customs Building.

Wherever the waste oil burner is to be installed, the economics of the project are quite favorable. The capital cost would be $11,000 for the collection tank and furnace while the annual savings on oil purchases would be over $4,000 a year. This would yield a payback period of 2.75 years and the net present value a 5 percent discount rate would be in excess of $30,000.

Implementation of this project should not be difficult, especially if the Highways Department decides to undertake the plan. The savings which would be available are substantial and this project should receive high priority for approval.

4.4 Diesel Generator Waste Heat

Electrical energy for the Beaver Creek community is presently supplied by diesel generators owned and operated by Yukon Electric Co. Ltd. The plant has an installed capacity of 800 kW, and consists of 200 kW, 250 kW, and 350 kW diesel generator sets.

The production of electrical power uses over 360,000 litres of fuel oil per year, representing about 14,000 gigajoules of energy. Previous studies indicate that electrical energy for the community will be provided by diesel generators for the foreseeable future.

The diesel generators at Beaver Creek convert between 25 and 30 percent of their input fuel energy into usable power. The remainder is transformed into heat which is carried from the engine by jacket water cooling, exhaust, and radiation, in the following proportions:

- 30% as waste heat to the jacket water/radiator;
- 30% as waste heat in the exhaust;
- 10-15% as radiation to the surrounding space.

Using heat recovery equipment, almost all of the jacket waste heat and about half of the exhaust waste heat may be recovered, which would increase the fuel utilization efficiency from about 30 percent to 75 percent. The recoverable waste heat, then, would be on the order of 6500 GJ/yr.

4.4.1 System Feasibility Criteria

For a waste heat recovery system to be feasible, it must be capable of delivering enough energy to a user building such that the cost of extending distribution piping to that building is justified. Thus, system design involves tradeoffs between capital costs (i.e., piping installation) and operating costs (i.e., fuel oil purchases). The amount of fuel oil saved will depend on how well the demand for heat and the supply from the system can be matched.

Most buildings in Beaver Creek depend on oil fired furnaces or boilers for space heating, and the present estimated space heating load is 18,985 GJ/yr. With the application of energy conservation measures, this load can be reduced by about 32 percent to about 12,880 GJ/yr.

For Beaver Creek then, the recoverable waste heat energy has the potential to displace a significant proportion of fuel oil energy used for space heating. In addition, one building complex, the AlasKon Border Lodge, is a significant user of fuel oil energy for domestic hot water heating in the summer.

The method for recovering the waste heat energy and distributing it to the load must be practical. The best method would be similar to a district heating system supplied by a central boiler. In this instance, the recovered heat would be transferred to hot water and distributed via piping to selected buildings. The recovery equipment, heat exchange transfer equipment, and end user equipment are manufactured items readily available in Canada. The principles of district heating systems are well known, with many thousands of installations existing in North America.

To limit pumping and piping costs, end users with a low load demand must be in close proximity to the diesel generator. Exact determination of suitable end users will depend on variables such as:

- optimum ratio of trench and pipe cost per meter versus GJ/a. of energy usage;
- incremental increase in central plant equipment cost for increased load;
- utilization factor for available waste heat;
- full time or seasonal occupancy/operation;
- type of load, i.e. space heating only, domestic hot water only, or combination.

4.4.2 System Optimization and Layout

The amount of recoverable waste heat is a function of diesel generator output, i.e. electrical power demand, which may not occur at the same time as peak space heating and domestic water heating demand. Therefore, a method of storing heat generated during peak electrical demand is required to permit distribution at some later time when generator output is low.

Although the AlasKon Border Lodge is some distance from the central plant, it is recommended for connection to the distribution system, even though it operates only from June to September. During this time, the rest of the community has relatively low space heating demands, but the Lodge has a high demand for domestic hot water heating, thus contributing to a higher system utilization. Otherwise, much of the available energy would go unused in the summer.

Similarly, the community pool has a relatively significant load for pool water and domestic water heating only during the summer months. Refer to Figure 4-2, which indicates the amount of recoverable energy that may be utilized by the pool and the AlasKon Border Lodge during periods of low space heating demand.

The Community Hall, School, and Highways Garage are large users of energy for space heating in close proximity to the diesel generators, making them prime candidates for connection to the system. Other buildings with lower load demands may be connected provided they are sufficiently proximate to the distribution mains to minimize the costs of service hook-ups.

Community peak electrical demand has not exceeded 240 kW in the past and significant future growth is not anticipated. This demand is normally met by operation of the 250 kW diesel generator set, with the 350 kW unit on line as back-up. Jacket and exhaust heat recovery equipment should be installed on the 250 kW unit, with jacket heat recovery only on the 350 kW unit. Use of the 200 kW unit should be limited to short periods of time or periods where heat demand is low.

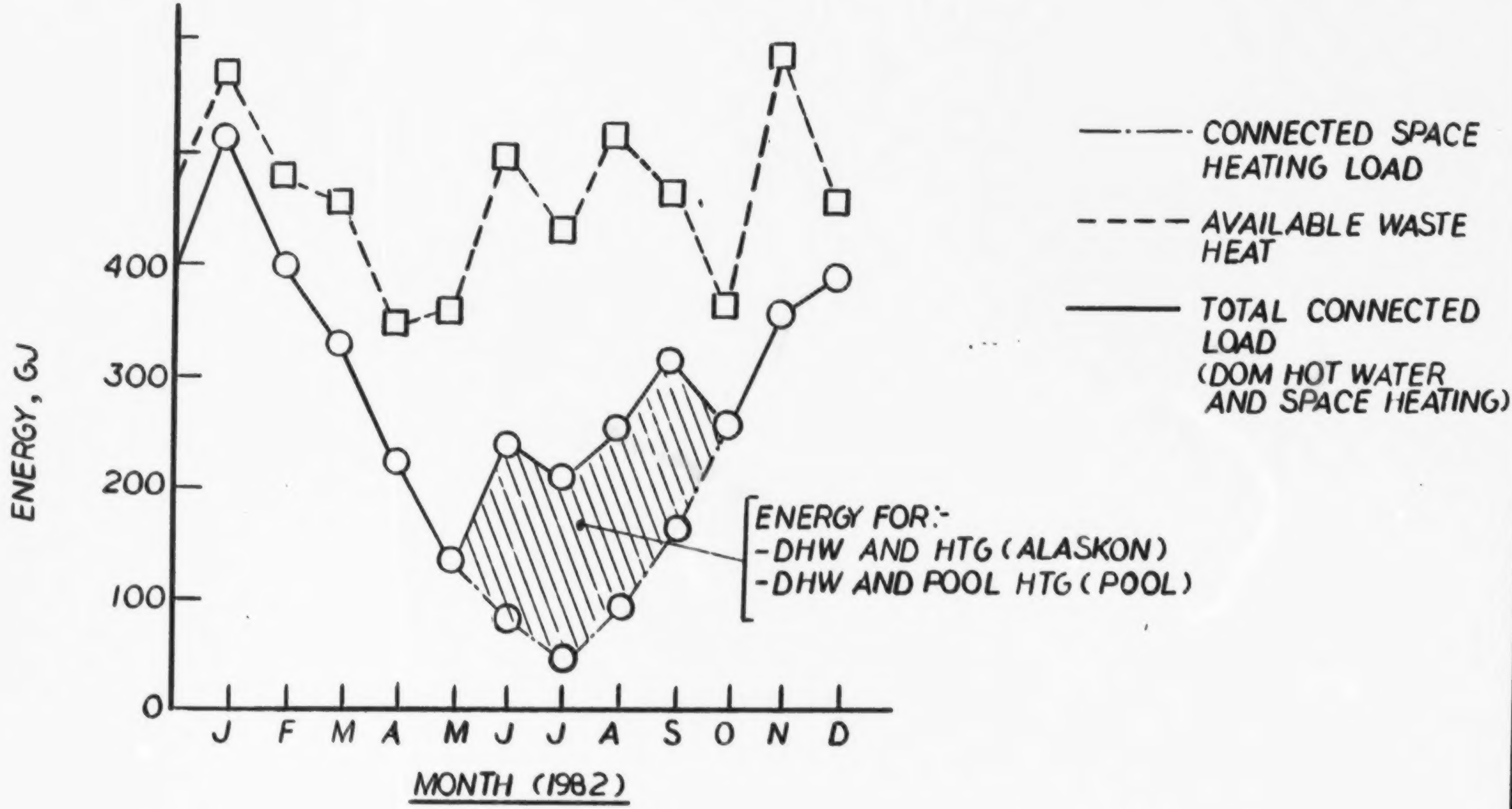


FIG. 4-2

BEAVER CREEK DIESEL HEAT RECOVERY SYSTEM

SUPPLY AND DEMAND

The storage capacity previously mentioned will also serve to maintain system utilization during shutdowns of the 250 kW unit for maintenance and for supplying nighttime heat loads when electric demand is relatively low.

Optimum storage capacity will be a function of such variables as:

- peak demand load;
- average demand load;
- system utilization; and,
- duration of maintenance shutdowns.

4.4.2.1 Central Plant

The central plant consists of the following equipment (refer to Figure 4-3):

- jacket water pipe loop, pump, and heat exchanger;
- exhaust gas heat recovery unit, pipe loop, pump and heat exchanger;
- 10,000 U.S. gallon (38,000 L) hot water storage tank;
- distribution pumps (duty and standby), expansion tanks, air separator, and differential pressure valve;
- temperature and pressure controls; and
- chemical treatment.

The equipment functions as follows:

- The heat recovery equipment transfers heat from the exhaust gas and jacket water to its respective heat exchanger, which in turn transfers the heat to either the storage tanks or the distribution system depending on demand.

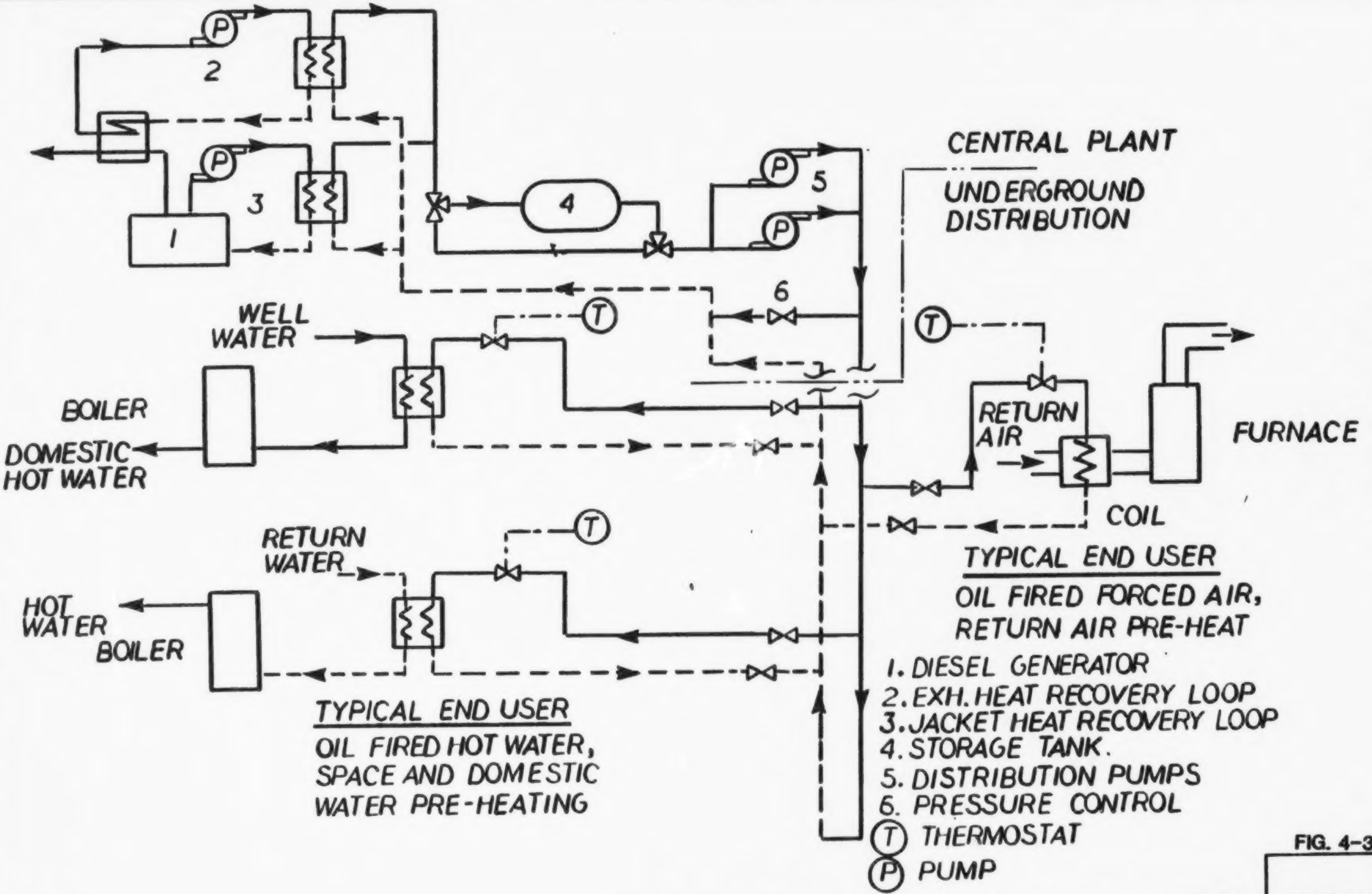

2
3
1
4
5
6
CENTRAL PLANT
UNDERGROUND DISTRIBUTION
WELL WATER
BOILER
DOMESTIC HOT WATER
RETURN WATER
HOT WATER BOILER
RETURN AIR
FURNACE
COIL
TYPICAL END USER
OIL FIRED FORCED AIR, RETURN AIR PRE-HEAT
TYPICAL END USER
OIL FIRED HOT WATER, SPACE AND DOMESTIC WATER PRE-HEATING
1. DIESEL GENERATOR
2. EXH. HEAT RECOVERY LOOP
3. JACKET HEAT RECOVERY LOOP
4. STORAGE TANK.
5. DISTRIBUTION PUMPS
6. PRESSURE CONTROL
Ⓣ THERMOSTAT
Ⓟ PUMP

FIG. 4-3

BEAVER CREEK DIESEL HEAT RECOVERY SYSTEM

SCHEMATIC

ACRES

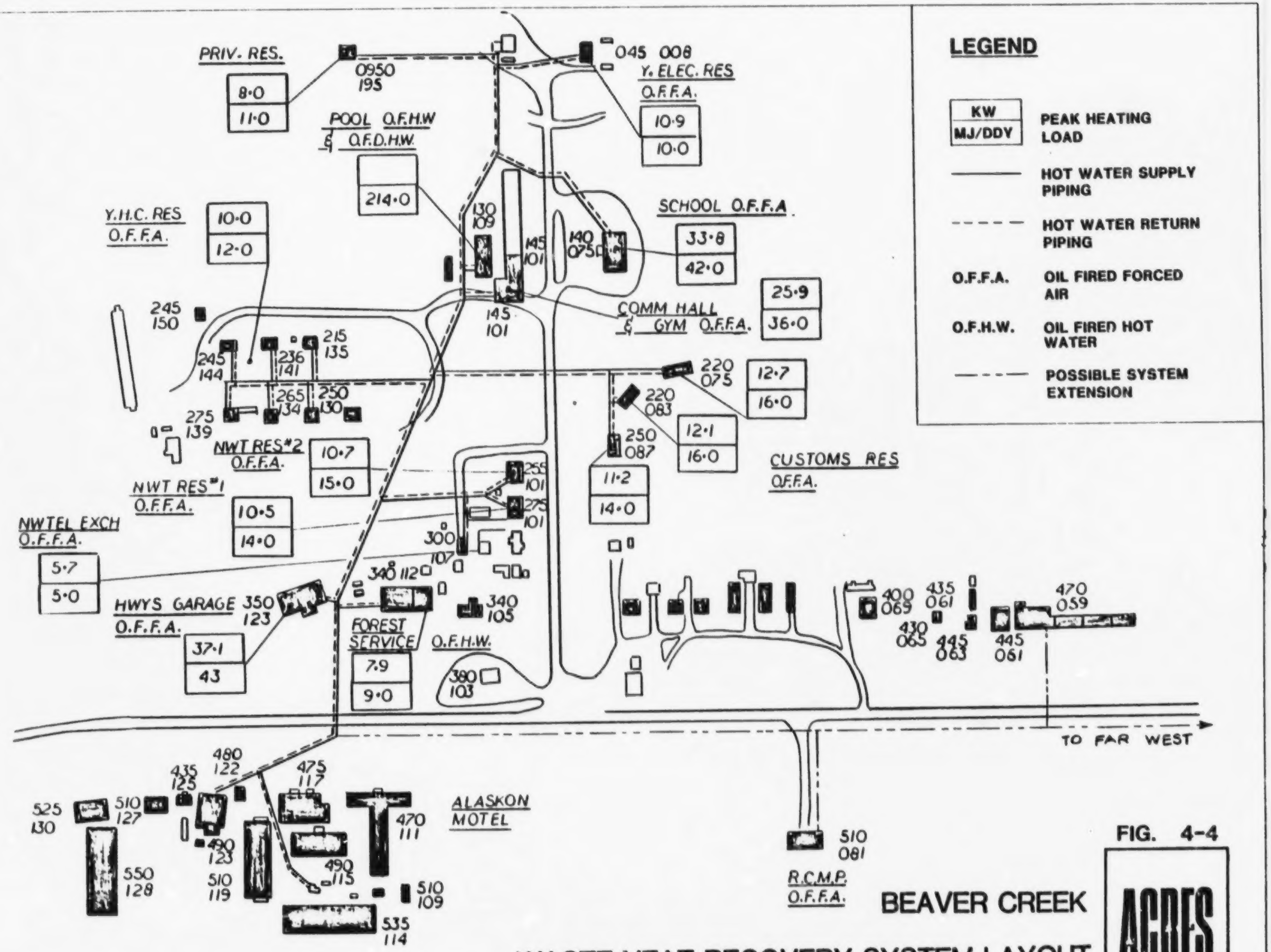
- As the heating load demand decreases, and storage is satisfied, the exhaust air bypasses the heat exchanger, and the jacket water is bypassed to the existing radiator.

- The distribution pumps deliver the heated water through the piping system to the end users. As end user demand decreases, system pressure in the direct return piping increases because of decreasing main pipe size, so the differential pressure valve bypasses a varying amount of hot water around the distribution system.

Because of the limited space availability in the existing diesel plant building, a small addition will be necessary to house the new equipment.

4.4.2.2 Distribution System

The pipe distribution system is shown in Figure 4-4. A direct return closed loop system carries hot water from the central plant to the buildings connected to the pipe grid. The insulated piping is directly buried in a shallow trench. (More elaborate trenching and pipe support systems would be necessary, if substantial areas of permafrost are found at or near the surface in Beaver Creek. Shallow trenching of one to two feet will be appropriate where permafrost is not encountered and no heavy vehicle traffic is expected.) The piping is supported, at 2 meter intervals, with wood blocking, and is backfilled with pit run gravel for good drainage. A protective wood cover prevents damage from future excavation. At selected intervals, expansion loops are required.



LEGEND
KW / MJ/DDY PEAK HEATING LOAD
HOT WATER SUPPLY PIPING
HOT WATER RETURN PIPING
O.F.F.A. OIL FIRED FORCED AIR
O.F.H.W. OIL FIRED HOT WATER
POSSIBLE SYSTEM EXTENSION
PRIV. RES.
8·0
11·0
0950
195
045 008
Y. ELEC. RES
O.F.F.A.
10·9
10·0
POOL O.F.H.W
& O.F.D.H.W.
214·0
Y.H.C. RES
O.F.F.A.
10·0
12·0
130
109
145
101
140
075
SCHOOL O.F.F.A
33·8
42·0
145
101
COMM HALL
& GYM O.F.F.A.
25·9
36·0
245
150
245
144
236
141
215
135
265
134
250
130
275
139
220
075
12·7
16·0
220
083
12·1
16·0
250
087
11·2
14·0
CUSTOMS RES
O.F.F.A.
NWT RES #2
O.F.F.A.
10·7
15·0
255
101
275
101
NWT RES #1
O.F.F.A.
10·5
14·0
NWTEL EXCH
O.F.F.A.
5·7
5·0
300
107
340
112
340
105
HWYS GARAGE
O.F.F.A.
350
123
37·1
43
FOREST
SERVICE
7·9
9·0
O.F.H.W.
380
103
400
065
435
061
430
065
445
063
445
061
470
059
TO FAR WEST
480
122
435
125
475
117
525
130
510
127
490
123
510
119
550
128
490
115
470
111
ALASKON
MOTEL
510
109
535
114
510
081
R.C.M.P.
O.F.F.A.

FIG. 4-4

BEAVER CREEK

WASTE HEAT RECOVERY SYSTEM LAYOUT

ACRES

At branch take-offs from the main, manholes are required to house the take-off fittings and balance valves. Small enclosures providing shelter to workers should be installed over the manholes.

The piping decreases in size from the central plant to the farthest connected load. As the hot water transfers its energy to the various loads, it is returned through similarly sized piping to the central plant.

To minimize transmission heat losses, all of the pipe and fittings require substantial insulation with a water impermeable jacket.

4.4.2.3 End User Equipment

Users with oil fired forced air space heating systems require the following additional equipment (Refer to Figure 4-3):

- heat exchanger;
- heating coil installed in the furnace supply air duct;
- piping connections to the distribution system;
- temperature control relay and control valve.

Almost all of the potentially connected users, with the major exceptions of the AlasKon Border Lodge the Forest Service Building and the pool, are in the above category.

The system functions as follows:

- On a demand for space heating the thermostat opens the control valve in the piping from the distribution system, allowing central plant hot water to flow through the coil to heat the air supply to the space, and maintain space temperature.

- On a further demand for heating, if the central plant water cannot maintain space temperature, the thermostat turns on the users' existing oil burner to supplement the peak heating demand.
- On a decrease in demand, the users' burner is turned off.

The system for the AlasKon Border Lodge consists of oil fired hot water space heating boilers with immersion coils for heating domestic hot water. The Lodge requires the following equipment:

- heat exchangers and controls in the hot water heating returns; and,
- heat exchanger and controls in the domestic cold water make up.

The space heating portion functions are basically as described above. The domestic water portion serves to preheat the cold water make-up, thus decreasing the amount of fuel oil energy required by the user to produce hot water.

4.4.3 System Costs

Capital costs are based on estimated equipment, piping, and installation prices for Yukon, in 1984 dollars.

Unit price for insulated pipe, installation, excavation and backfill averages $120/m of distribution system length. The distribution system piping was sized using a system temperature differential of 11°C between hot water supply and return piping.

Based on the sytem configuration shown in Figures 4-3 and Figure 4-4, total capital costs are estimated at close to $300,000. Distribution costs represent the largest component of the capital estimate at $182,000. This is based on the shallow trenching methods described above. If more complex installation techniques are required due to soil or permafrost conditions, these costs could increase dramatically.

Pipe mains would be between 4" diameter and 2" diameter depending on location. Individual building service connections are sized at 1" or 1-1/2". Costs for pipe, fittings and insulation range from $23 per meter for 1" to $74 per meter for the 4" runs. Trenching is estimated at $40 per meter for all pipe sizes.

End user equipment for buildings with oil-fired forced air furnaces would be about $750 each for the heat coil, control and piping between the furnace and the property line. Slightly greater expenses are anticipated for the AlasKon Border Lodge, the Highways Garage and the Community Hall and pool. These would cost between $2,000 and $3,500 to convert.

The total system capital costs are summarized in the following Table 4-1.

TABLE 4-1

SUMMARY OF TOTAL SYSTEM CAPITAL COSTS

● Plant and Equipment		
- Central Plant Equipment	$50,000	
- New Building (46 m2)	25,000	
- Contingency, 10%	7,500	$ 82,500
● Distribution System		
- Piping	$101,950	
- Trenching	62,200	
- Contingency 10%	17,950	$182,100
● End-User Equipment	$ 27,000	
- Contingency 10%	2,700	$ 29,700
Total		$294,300

Operation and maintenance procedures are essentially similar to those for a hot water heating system, with the heat recovery equipment substituted for a hot water boiler. However, there are more sophisticated control requirements to give proper operation of heat recovery and storage. An engineered system would be complete with step by step preventative maintenance procedures, which might include:

- Daily - visual inspection of central plant for leaks and pump operation;

- Monthly - pump lubrication, chemical treatment;

- Quarterly - visual inspection of distribution system (walk-through to detect hot spots above ground to indicate leaking);

- Yearly - check and recalibrate controls; check heat exchangers, heat recovery equipment, user's equipment.

An experienced heating service contractor might be engaged on a contract basis to perform the more stringent annual maintenance procedures.

Moving parts are essentially confined to pumps and controls, and a modest spare parts inventory could be maintained to cover normal pump or controls breakdown.

Allocated time for maintenance functions is estimated as follows:

- daily - 1/2 hr.
- monthly - 2 hrs.

- quarterly - 4 hrs.
- yearly - 4 man days

This allocation indicates a total of about 200 hours per year in maintenance labour. Costs for this labour would be about $3,000 annually. Ideally, someone with mechanical expertise in the community could be contracted for this work. An allowance for spare parts, lubricating oils, glycol and miscellaneous tools amounting to about $1,500 per year should also be included in operating costs.

The other component of operating costs will be the electrical energy used by the distribution pumps. The system will require continuous operation of a circulation pump which will draw 6 kW of power. If 3 kWh are obtained from a litre of diesel fuel costing 46¢, then the cost per kWh is 15.3¢. The annual energy cost for the pumps can thus be calculated as: (6 kW x 8760 hrs/yr x $0.153/kWh) = $8,060/yr.

4.4.4 System Economic Assessment

The value of the diesel waste heat recovery system described in the foregoing subsections will depend on the quantity of heating oil purchases which can be avoided. To identify this quantity, it is necessary to analyze the supply and demand characteristics which will apply.

Based on the building energy surveys and recommendations for conservation, it has been determined that the connected space load would be 386 MJ/DD for May through September and 303 MJ/DD for October through May. The reason for the difference is that the AlasKon Border Lodge is not heated during the winter. In addition to the space heat demand, hot water heating for the community pool and the AlasKon Border Lodge are included in the connected heating load. This amounts to an additional 159 GJ/mo. between May and September.

Total load calculated in Table 4-2 is based on the actual 1982 generation output, the number of degree days recorded in 1982, and the building connections indicated in the discussion of the distribution system. As can be seen, the total demand ranges from a high of 514 GJ in January to 206 GJ in July.

The available waste heat varies with the diesel generator output. As shown in Table 4-2, the recovery system will supply enough energy per month to satisfy the average monthly load. More than double the necessary energy is available during the summer months but the excess supply is much smaller in the winter. Total load demand on an annual basis is 3615 GJ, while the total energy supplied by the recovery system is 5527 GJ.

Thus, it would appear that all of the heating oil currently used to heat the connected buildings could be displaced. In that case, it might be appropriate to consider the connection of more buildings, or perhaps the use of the recovery system for more DHW heating in buildings already connected. However, it should be noted that the monthly totals in Table 4-2 mask the peaking characteristics of heat demand.

During peak demand periods (i.e. the coldest days), energy requirements in the connected buildings would be about

TABLE 4-2

DIESEL WASTE HEAT SUPPLY AND DEMAND

Month	DEMAND Conn.Htg. Load, MJ/DD	DD*	HTG Load GJ/Month	DHW HTG Load, GJ/Month	Total Load, GJ/Month	SUPPLY Recovery Heat, GJ/Month*
Jan	303	1696	514	-	514	575
Feb	303	1321	400	-	400	478
Mar	303	1082	328	-	328	457
Apr	303	738	224	-	224	349
May	303	434	132	-	132	359
Jun	386	211	82	159	241	495
Jul	386	121	47	159	206	430
Aug	386	239	92	159	251	516
Sep	386	406	157	159	316	464
Oct	303	849	257	-	257	366
Nov	303	1181	358	-	358	585
Dec	303	1280	388	-	388	453
		9558			3615 GJ/yr	5527 GJ/yr

* Based on 1982 Degree Day and actual electrial generation data.

2.3 times the requirements for the average day. When this occurs the supply from the recovery system will not meet the demand and the end users' oil-fired furnaces will be required to supply supplemental heat. To determine the exact extent to which peak demands will exceed the supply, it would be necessary to analyze hourly temperature records and compare these with hourly electric generation data. Such detailed data has not been available for this study.

Experience with operating systems shows that for some percentage of the time, the load demand will be greater than the heat supply. The converse will also be true, that is, for some percentage of the time, the available heat from the recovery system will not be required or used. Therefore, the beneficial energy gained from the heat recovery system is less than total demand and less than total available.

Since average demand is the lower of the two, it will control the amount of savings achieved. The excess supply in all but the two coldest months of January and February is such that peak demands would probably be satisfied by the recovery system. Storage capability on the system will also help modify the effects of non-coincidence between generating peaks and heat demand peaks. Taking these factors into consideration, it is estimated that the utilization factor on the system will be 90 percent of demand. The other 10 percent of the demand would be met by peaking operations on the conventional furnaces.

With this utilization factor, it is possible to value the project and the fuel oil displaced. Table 4-3 shows the economic analysis and results. Based on the indicated

TABLE 4-3

ECONOMIC ANALYSIS OF DIESEL WASTE HEAT RECOVERY SYSTEM

Capital Cost: $294,300

Annual Operating Cost: $12,560

Annual Energy Supplied: 3615 GJ (.90) = 3250 GJ

Annual Oil Displaced:

Net Energy per Liter with 60 percent combustion efficiency:

(37.6 MJ x .60) = 22.6 MJ/L

(3250000/22.6) = $144,215 L

(144000 x $0.46/L) = $66,200

Net Annual Cash Flow:

(Oil Savings - Operating Costs)

($66,200 - $12,560) = $53,640

Payback Period:

($294,300 ÷ $53,640) = 5.5 years

Net Present Value: (15 - year project life)

@ 5% discount rate	$262,500
@ 10% discount rate	$113,700

Internal Rate of Return: 16%

assumptions, the proposed heat recovery project will result in savings of 144,000 litres of fuel oil per year and has a payback period of only 5.5 years. The return on the investment is 16.4%. This is considered very attractive in the sense that this represents a "real" return after the effects of inflation are taken out. All of the dollar amounts are presented in constant 1984 dollars. On this basis, the recovery system is a recommended alternative for Beaver Creek.

4.4.5 Other Considerations for Recovery System

The system configuration presented in the preceding subsections is the one which achieves the shortest payback period and yields the greatest return on investment. However, other objectives or constraints might suggest other arrangements.

For example, in the system above, about 2,275 GJ of waste heat energy go unused, primarily because of non-coincidence of supply and demand. One way of increasing the utilization would be to extend the distribution system to additional load centers. The logical extension would be along the highway to connect the RCMP Detachment, Ida's and the Far West. This would increase the system capital costs by approximately $115,000 and the operating costs would go up about $3,000. Total connected demand would increase to 5,386 GJ but since the demand is virtually the same as the supply, a lower percentage of each user's requirements would be met by the system. Depending on the peaking patterns, the average percentage supplied might fall to 75 percent or 80 percent. As would be expected, each incremental expansion to the system will provide diminishing returns. Eventually, a particular increment will provide no return at all. However, as long as a system extension reduces oil consumption enough to justify the cost of the extension, it is in the community's interest to undertake it.

Another system enhancement which should be contemplated is the connection of domestic water heating tanks. The school and the residential buildings connected to the system are estimated to require about 35,000 kWh annually for water heating after the recommended conservation measures are in place. The average residence consumes about 2,450 kWh annually for water heat. Since the distribution system would be connected to the building's furnace already, connection of a heat exchanger to the inlet pipe of the water heater would require only about $300 in additional investment. At a cost of 27¢/kWh, the annual savings for that residence would be about $660. The oil savings resulting from the reduced electrical generation demand would be about 11,700 litres with a value of over $5,000 per year. Clearly, this step should be taken if the heat distribution system is installed.

As discussed in Section 4.2 regarding wood fuel opportunities, a wood-chip fired boiler could be considered for supplying supplemental energy to the distribution grid. As well, other sources such as waste-oil, geothermal or peat could pump energy onto the grid. To determine whether any of these options are economically attractive, it is necessary to compare the incremental costs with the incremental oil displaced. Detailed demand records are required for such an assessment however and at present, are not available.

Finally, in the planning of a heat recovery system for Beaver Creek, recognition must be given to the complexities of institutional relationships, the responsibility for costs and the means for collecting revenues. Basically, the diesel generators are owned by YECL, the potential customers are various federal and territorial government departments, private businesses and individuals. It is not a simple matter to determine who should install, own and operate the sytem. Probably, a cooperative arrangement between YECL, the federal government and the Government of Yukon will be required.

As for collecting the revenues, it may be difficult to establish the monetary value of energy distributed to individual users. The ultimate price to the consumer must be less than conventional heating costs to provide an incentive to connect to the system. Assistance with the initial installation costs may also be required. Ideally, charges would be based on the units of energy used by the consumer. However, meters capable of measuring energy deliveries are relatively complex and expensive, since the unit must analyze flow rates, incoming temperatures, outgoing temperatures and time. Simple flow meters are available but they cannot indicate how much energy was actually extracted from the passing water. Integrating energy meters have been used in Europe for many years. They are not prohibitively expensive (500 - 800 $/unit) and have been used in the N.W.T. For large user buildings an integrating energy meter is probably justified. For residential buildings however, it may be necessary to determine somewhat more arbitrary means of billing, based on factors such as supply capacity, past energy usage, building volume and degree days.

4.5 Solar Energy

Solar energy has been proven as a practical source of energy for space and water heating in Yukon. It would certainly be expected that solar energy could be utilized in Beaver Creek as well. Solar energy applications include active systems, that is systems requiring another source of power to operate them, passive systems which require no external mechanical work, and photovoltaic systems which produce electric power. Photovoltaic applications have not been found to be practical for remote community applications requiring 250 kW power potential and would undoubtedly be uneconomic in the Beaver Creek setting.

Active solar systems are in use in Yukon for heating municipal pools as well as some buildings. These systems are especially practical where the demand coincides with the summer months, as is the case with swimming pools. In Beaver Creek, there are two centres where utilization is concentrated in the summer and large hot water heating requirements are imposed, namely the community pool and the AlasKon Border Lodge. In either case, the system would consist of roof mounted or open field mounted collectors to capture the heat, a pump and piping to move the hot water inside the building. In the case of the pool, the warmed water would be used directly. At the AlasKon Border Lodge, the water would be delivered to a storage tank. The water in the storage tank can either be drawn upon as preheated water for the existing boiler or for direct use. The technology is relatively straightforward, but the cost of such systems tends to be quite high. In a situation where the pumps are operating on diesel generated electric power, the operating costs can also be significant.

The principal difficulty with using solar systems for the AlasKon Border Lodge water heating, is that the storage requirements would entail exorbitant costs. Most of the solar energy is available mid-day but the demand is concentrated in the evening and early morning. The facility is virtually empty mid-day. Therefore, to use solar, massive storage capacity would be necessary to save the hot water until it is needed.

Passive solar energy can supply between 25 and 75 percent of the space heat requirements of buildings. Basically, the structure is designed to maximize the glass area on the south face of the building and allow the building itself to be a solar collector. It is also necessary that the building be quite well insulated to avoid heat loss and that thermal insulation be applied to the window space during the night. Depending upon the building, the costs for renovation to achieve greater solar gain can be minimal or quite significant. For newly constructed buildings the costs for incorporating passive solar features are quite small (i.e. less than 10 percent) and the energy savings can be quite significant.

In planning for future buildings in Beaver Creek, every effort should be made to orient the building on the lot such that the longest wall will have a southern exposure. The building design should then incorporate provision for most of the glass area to be facing south and a minimum of glass on the northern face. In addition, attached greenhouse structures on the southern walls of buildings can provide significant heat to the building. These can be incorporated into existing structures or new structures. This simply has the effect of increasing the solar collector area of the building. Even in the winter months, there is substantial solar energy available. A well conceived and constructed greenhouse installation, along with other measures to maximize solar gains, can provide sufficient space heat energy to displace in excess of 35 percent of the oil fired heat energy required.

It would be difficult to adapt most of the buildings in Beaver Creek to increase solar gains without substantial renovation expense. However, there is no reason to overlook this substantial source of energy for new buildings and every effort should be made in community planning to achieve this.

4.6 Other Alternatives

Investigations at Beaver Creek have indicated that those oil reduction options discussed above represent the most promising alternatives to conventional energy supply in the community. Increased wood burning, waste oil recovery, diesel waste heat recovery and passive solar, when combined with conservation provide promising economic results and significant oil displacement.

Several other possible energy sources were investigated in the course of this study, but have been found to lack the basic prerequisites for detailed analysis. Briefly, those alternatives which have been rejected for Beaver Creek include:

- Small Hydro

Aerial investigations and analysis of topographic maps for the Beaver Creek area failed to reveal any promising small hydro sites. Based on the load requirements in Beaver Creek, it would not be economic to consider hydro sites more than about 12 km distance from the community. Within that radius, there is very little elevation change on creeks which would be expected to have sufficient flow to support electrical generation. Without some elevation drop, or lead, run of the river turbines would develop very little power. In addition, the creeks in the area tend to flow in relatively broad flat basins which would not be amenable to damming at reasonable costs. Finally, the climate of the area is such that several of the creeks which may carry sufficient annual flow to generate electricity, would be virtually frozen solid during the winter. Even if some flow continued, the potential for icing up of system components presents considerable difficulties.

- Biogas

There are no significant sources of organic wastes in the Beaver Creek area. Even if such material were available, it is unlikely that the energy balance resulting from a biogas generation plant in Beaver Creek would be economically favourable. It is necessary to heat the biogas generation process to about 35°C to obtain optimal results. In the Beaver Creek climate, virtually all the energy produced by the process would have to be used to maintain this heat. Since there is presently no central sewer system in Beaver Creek, collection would impose a further disadvantage ruling out such an option for the community.

- Geothermal Energy

Previous studies have not identified any surface evidence of geothermally heated water in the area. Development of deep aquifer geothermal systems is quite an expensive undertaking and can only be justified where very high, concentrated heat load demands are available. For example, if geothermal gradients in the region are similar to those found in Northern Alberta and B.C. (30°-50°C/km), production and reinjection wells would be a minimum of 1000 metres deep to supply geothermal fluid suitable for space heating uses. The capital costs of such a system, excluding any distribution piping would exceed $1.5 million. Operating costs for the system would be on the order of $150,000 per year, depending on how much pumping is required. Geothermal development is very expensive and unless there is evidence of near surface geothermal activity, such developments are likely to exceed the scale possible in small communities. Thus the overall system would be far more expensive than a diesel waste heat recovery system. It would take substantial geotechnical investigations to determine whether there is physical resource in the vicinity of Beaver Creek.

- Grid Extension

Virtually all oil consumption for space heating and electric generation could be displaced in Beaver Creek by connecting the community to Yukon hydroelectric transmission grid. The nearest point for such a connection is near Haines Junction, some 250 km southeast of Beaver

Creek. Since a transmission line to Beaver Creek could generally follow the Alaska Highway corridor, construction difficulty should not be extreme. Even with this advantage however, it would be expected that construction costs would be near $40,000 per km. To this would be added the cost of sending and receiving sub-stations and conversion of building heating systems to electric element heaters. At a mininum, total project costs would be in excess of $10 million. Assuming all space heating requirements in Beaver Creek are converted to electric, the expected savings in oil purchases would amount to about $400,000 per annum. These avoided costs would be offset by the cost of purchases from the grid. At 5¢/kWh and a post-conservation demand of about 27,000 gigajoules, the purchase price for the electricity will be on the order of $375,000 per year also. Thus, the total cost of transmission from the grid would be the amortization on $10 million, or roughly $1 million per year to achieve an annual savings of $25,000. Clearly the demand for electricity in Beaver Creek is not nearly sufficient to justify the enormous expenditure associated with transmission over such long distances.

- Coal

At the present time there is no coal production taking place on a commercial basis in Yukon. Because of its bulk, coal is more expensive to transport than oil on a energy per ton basis. Therefore, coal from northern B.C. or Alberta trucked to Beaver Creek could not compete with oil. Furthermore, a number of technological problems are associated with using coal for electrical generation. Steam turbine thermal generating plants are highly complex and must be of a relatively large size to be economic. In addition to the equipment requirements for the actual burning of the coal, steam conversion and driving the turbine generators, a great deal of investment and infrastructure is required for the delivery, stacking, reclaiming and conveying of the coal fuel. Projects of this nature far exceed the capabilities of small remote communities. Coal could also be used much like wood in small stoves and furnaces for space heating. The energy content of coal is higher than wood and provided the stove is designed to withstand the higher temperatures associated with burning coal, it serves as an excellent substitute for wood fuel. The difficulty for Beaver Creek is a matter of supply. Wood fuel could be obtained nearby relatively easily, while coal would have to be trucked over long distances. Eventually, if there is substantial industrial demand to warrant it (such as the re-opening of the Cyprus Anvil Mine), coal production may commence on a commercial basis in Yukon. Exploration and feasibility work has been conducted on coal deposits near Whitehorse. Under these circumstances, lower cost coal may be available in the future. It may at that time be an appropriate alternative to oil or wood fuelled space heating requirements.

- Wind

Even in areas that are known to be relatively windy, wind power electic generation has not been yet found economic. Experience gained from pilot projects elsewhere in Canada indicates that wind turbines of a size appropriate to small remote communities would deliver energy at a cost close to 50¢ per/kWh. As inefficient as diesel generators are, they are still about half the cost of wind turbines. Furthermore, wind generation is not reliable since the energy is only available when winds are running between 20 and 55 km/h. The capital cost for wind generators is an order of magnitude greater than those for diesel generators. Therefore, for the foreseeable future, it is not expected that wind generation will be competitive. There is no specific indication that winds in the Beaver Creek area are extreme or constant enough to consider further the feasibility of wind generation.

- Peat

There is some evidence that deposits of peat bog may occur in the Beaver Creek area. Also, since the climate is relatively dry, there would be a reasonable probability that air drying of the bog could be relatively effective such that moisture content of the fuel would be brought down to the area 50 percent. Even at this rate, however, the combusion efficiency for peat in conventional home furnaces or air tight stoves would be expected to be a relatively low 20 percent. Basically peat can be used in much the same way as fuel wood and the decision on whether or not to pursue peat harvesting depends on whether wood is available as an alternative. In the case of Beaver Creek, the collection of fuel wood will entail less cost and effort than the harvesting of peat. On that basis, it would have to be considered a secondary option at this time.

- Propane

Propane can be used for cooking, hot water heating, and space heating but it suffers from some of the same disadvantages as coal. Specifically, the energy content of propane on a per unit volume is less than that for heating oil or stove oil and the transportation per unit is much more expensive. As a result, the delivered price of usable energy is greater than for oil products. Unless the present regime of pricing arrangements between the producing provinces and the federal government is altered in favour of propane, it is not expected that it will be an economic substitute fuel for anything other than cooking purposes.

5.0 IMPLEMENTATION PLAN AND RECOMMENDATIONS

5.1 Introduction

In the Phase I report on building energy requirements and this Energy Plan Report, it has been established that many of the buildings in Beaver Creek, and the energy supply itself, operate less efficiently than is possible. This results in unnecessary energy expenditures by building operators, and needless waste of petroleum products.

As noted in the "Remote Northern Community Energy Planning Handbook," community energy planning involves a process including a number of distinct steps and a continuing awareness and desire to pursue efficient energy management in the community.

Many of the steps outlined in the Energy Planning Handbook have been completed for Beaver Creek. Basically, the energy problems have been identified and the solutions have been proposed. Implementation is the remaining stage of the process. Some issues require further detailed assessment, but the immediate needs of the community can be addressed forthwith.

The procedures, alternatives and recommendations have been presented and discussed with individuals and groups in Beaver Creek. An open meeting was held in the community at the commencement of the project to advise attendees of the various options which were to be investigated. The preliminary findings regarding feasible energy supply options, which were derived from the Yukon Energy Overview Study were presented.

Subsequently, three members of the study team spent two weeks in the community, during which time every building operator/owner was contacted. Specific conservation opportunities associated with their buildings were discussed in addition to community-wide energy problems and alternative energy resources for the community.

As a result of these sessions, some of the recommended actions listed in this report have already been implemented by building operators, and the resulting energy savings are already being realized. For example, several measures to reduce hot water consumption in one highway lodge have been implemented as a result of this exercise, and another has converted much of its heating from oil to wood.

Various community members repeatedly expressed interest in the feasibility of a diesel waste heat recovery system for the community. Details of this proposal, as well as the findings with respect to other options, were presented at a community meeting as well as in individual discussions with residents.

Furthermore, a special program was presented to children attending the school in Beaver Creek on energy issues. Causes of energy waste in households and remote communities in general were discussed. Ways of saving energy and obtaining energy from non-oil sources were highlighted.

For the most part, the private sector in Beaver Creek has already responded to the first recommendation of this Community Energy Plan by substantially substituting oil with fuel wood for space heating requirements. Those who purchase their own fuel have almost completely converted. Due to restrictions on wood stoves in federal government housing, however, this sector still relies almost entirely on oil. Changes in federal policy will be necessary to correct this situation.

5.2 Socio-Economic and Environmental Impacts

The conservation measures and alternative energy strategies which are being proposed for Beaver Creek do not encompass significant socio-economic or environmental impacts. Reference to specific employment opportunities generated by the implementation of proposed measures has already been made at appropriate points in the text. Where feasible brief reference has also been made to environmental ramifications. The following discussion relates to general socio-economic and environmental factors which should be considered in the context of implementing the proposed measures.

Unfortunately, Beaver Creek is not typical of the majority of northern communities. Close to 50 percent of the buildings are government owned while another 35 percent are owned by companies. Much of the full-time work force is employed by government agencies. The demography of the community is constantly in transition as many government workers are rotated on a periodic basis and workers at the AlasKon Border Lodge are only in Beaver Creek during summers. Given the isolation of Beaver Creek, its transient population and the fact that many people in the community are either given, or are subsidized, in their housing, living expenses and even energy bills it is difficult to integrate long-term, stable energy planning measures.

When evaluating socio-economic and environmental impacts the above factors tend to limit the extent of long term social impacts. Undoubtedly, the installation of conservation measures within individual structures will create some or local regional employment. It is likely that the implementation of larger projects will require the services of contractors based outside Beaver Creek, as there is no construction industry in the community.

Some local employment opportunities exist in the context of enchanced utilization of regional wood supplies. As noted elsewhere in the text, approximately one (1) man-year per annum of employment could be generated for the purpose of harvesting and distributing wood supplies for fuel use within Beaver Creek. The installation of the waste heat recovery system would also generate new employment on a short term basis.

Conversion of the highways garage heating system to accommodate waste oil requires some mechanical modifications. However, these are not extensive and will not generate significant additional employment. Adverse socio-economic impacts associated with any of the proposed are not immediately evident. The economic costs and benefits associated with implementation of the various measures has been described elsewhere in the text of this report.

As with social impacts, the environmental ramifications of implementing the proposed conservation measures are minimal. Additional opportunities for utilization of wood stoves, would generate more smoke and increase particulate loading levels in the local air shed. However, as the number of structures within Beaver Creek is extremely small relative to most population centres, and as ambient air quality levels are excellent, no significant air pollution problem is foreseen.

The implementation of a waste oil recovery system would have positive environmental impact arising from better usage of resources and the elimination of a need to dispose of waste oil. The chemistry of waste oil is somewhat different from that of regular heating oil which would in turn contribute to slightly different flue gas characteristics. However, here again the impacts are not considered significant.

The waste heat recovery system would require the laying of buried pipe throughout Beaver Creek. While the pipe is of small diameter and the excavation depth is not great, limited soil mobilization and subsidence of the active layer through disruption of permafrost zones, is a possibility. Northern contractors are however familiar with appropriate construction procedures under these circumstances, and mitigative measures can be easily undertaken in the course of construction. No long term environmental effects arising out of the development of the waste heat system is envisaged.

Finally, it is widely appreciated, that regeneration cycles for Northern forests are extremely attenuated. Augmenting local wood supplies would have a positive effect on the communities cummulative energy consumption rate. Yet, simultaneously, care must be taken to ensure that wood supplies are not depleted in a manner inconsistent with sound forest management practice. Undoubtedly, any increased utilization of wood resources within the region would be conducted with the knowledge and input of forest management personnel with jurisdiction in this area. With their contribution, it is assumed that the limited amount of wood required to augment current wood consumption rates will be achieved in an acceptable manner.

5.3 Implementation Steps

Through the planning steps documented in this report and the Phase I report, it has been determined that close to 30 percent of the present oil expenditures for space heating in Beaver Creek can be avoided. In addition about 4 percent of the electrical consumption can be eliminated. At the same time, the comfort of building occupants will remain at equivalent levels, or actually improve. To achieve these benefits, the conservation measures recommended in this and the Phase I reports must be undertaken.

The potential for displacing oil consumption in Beaver Creek need not end there however. A number of alternative energy sources have been shown to be practical and cost-effective for application in Beaver Creek.

Specifically, the actions which are recommended are outlined in the following paragraphs, in the order in which they should receive priority for implementation.

1. The Government of Yukon Energy and Mines Branch should disseminate the individual building analysis data sheets to all building owners/operators. These were appended to the Phase I report on Beaver Creek. The data provided outlines the analysis of building energy consumption, describes specific conservation measures and estimates the energy savings resulting from these

actions. Cost estimates are included for each activity and a life cycle costing financial assessment for the conservation projects is provided. The costs and benefits of conservation for each building are clearly identified and can be used by building owners to budget for upgrading.

For reasons of confidentiality, the building specific data will only be available to the building owners. However, on a community wide basis, the estimated cost of recommended conservation projects is $120,000. The resulting annual savings will be close to 7000 GJ valued at about $75,000. Assuming a conservative life of 5 years for these improvements and a 10 percent discount rate, the present value of these savings are over $280,000 and the benefit/cost ratio is 2.4. Many of the individual projects far exceed this ratio.

2. To secure these benefits, it is recommended that one week energy theory/economics seminars should be presented to a "committee", consisting of employees of the major landlords in Beaver Creek. Participation in this course would have to be strongly supported and recommended by the respective government employer departments. The course would also be open to private businesses or residents in Beaver Creek.

   The intent of the seminars is to initiate action on Step 6 of the Energy Planning Handbook - Identify, Develop, and Utilize Local Resources. To put the purpose of the seminars in context, the seminars should start with presentation of the video on Energy Planning which was done for the Beaver Creek Study.

These personnel would be trained in the interpretation of the data collected for this study and would establish retrofit schedules for the buildings within their jurisdictions with the highest calculated energy savings per investment.

In conjunction with the "committee" selection of buildings to be retrofitted, a two-week hands-on training program for local carpenters and contractors should be implemented as the first retrofit project on the schedule to initiate the conservation projects.

Coordination of this program should be undertaken by Energy & Mines Branch with the support and cooperation of the Department of Municipal Affairs and appropriate federal government departments.

3. In order to pursue appropriate alternative energy supply options, it is recommended that a consortium comprised of the Department of Municipal Affairs, the Energy and Mines Branch and Yukon Electric Company Ltd., serve as proponents for an energy demonstration project in Beaver Creek under Phase 2 of the Remote Community Demonstration Program.

   Feasibility of the principal opportunities has been established in this report and are noted below. Each now requires a detailed technical assessment, and the assembly of project finances. Projects should be undertaken in order of best return on investment. Based on the assessments reported here, projects in decending order of financial attractiveness represent the subsequent steps of the energy plan.

4. Increased utilization of wood fuel for space heating in the residential sector represents the best investment in energy supply. Most of the residences in Beaver Creek are owned by either the federal or Yukon governments, and almost no wood is consumed in these. There are apparently some institutional constraints which restrict wood burning in government owned housing. These policies should be reviewed and modified. At the same time policies which remove the financial incentive for using wood by government employees should be changed.

   The project planning consortium, in consultation with forest service officials in Beaver Creek, should undertake a detailed inventory of the wood supplies in the vicinity of the community. Also, a means for organizing a reliable wood supply system should be developed. Since most of the residents in Beaver Creek are full-time employees of various government departments, it is unrealistic to expect them to also collect and deliver wood supplies on a large scale.

   It is likely that there are local people who are underemployed in the winter months and who could be contracted for the wood supply services. Since government will be the chief beneficiary of savings in oil purchases, an appropriate contract arrangement should be spearheaded by a government sponsor (i.e., Municipal Affairs).

   The resulting local employment would provide for the equivalent of about one man-year per year in Beaver Creek. The work would actually be conducted by 2 or 3 persons primarily during the winter months.

Overall costs for this project would entail capital expenditures of about $42,000 to provide wood burning furnaces to the 28 residential buildings which are not burning wood in Beaver Creek. At $100 per cord, the annual expenditures for fuel would be another $30,000. Offsetting these costs would be savings of over $50,000 in oil purchases. If it is assumed that the average life of residences converting to wood is 10 years, then the present value of the net annual savings of $20,000 at a 10 percent discount rate is $122,000, yielding a benefit cost ratio of about 2.9. The payback period is a very reasonable 2.1 years.

5. The energy planning consortium, with Yukon Department of Highways, should commence immediate detailed design investigations for utilizing waste oil at the highways complex in Beaver Creek. The economics of this option are quite attractive and there is no reason to delay implementation except for the possibility that a centralized district heating system might be installed in the future. Once more is known about this possibility, it will be necessary to decide whether to proceed with the waste oil project anyway, or whether the waste oil might be appropriately utilized in a building that is not likely to be connected to the district grid.

   The first step in implementing this project would be soliciting suppliers of mixed waste oil and heating fuel furnaces to obtain specifications, operating requirements and prices. Detailed design specifications should also be developed for the collection system and storage tank. Installation of the tank and the commencement of oil collection could occur prior to the purchase of the furnace so that a quantity of fuel will be available immediately. Other community residents should be advised of the location of the tank and procedures for depositing their own waste oil in the container. YECL, Far West and other potential sources of larger quantities of waste oil should be approached to discuss with them how their wastes may best be obtained.

Capital costs for this project are estimated at only $11,000, while the oil purchases avoided would amount to about 9,000 litres valued at close to $4,000 annually. The payback period would be 2.75 years. With an assumed life of 10 years and a 10 percent discount rate, the present value of the savings are about $25,000 to yield a benefit/cost ratio of 2.2.

An added advantage of the implementation of this project is that a costly waste disposal problem is eliminated which adds to the economic benefits and reduces the threat of negative environmental impacts.

6. Once the conservation measures have been implemented, a waste oil system installed at the highways facility and wood introduced to the residential sector, it will be necessary to re-evaluate the energy consumption patterns of the community. The relatively low cost opportunities recommended above will have a dramatic impact on overall energy demand. Records for the heating season following the implementation of these projects will reveal how effective they have been. With this data, it will be possible to pursue additional alternatives.

7. Assuming the assessment conducted in Step 6 indicates sufficient remaining need, detailed technical studies in support of a diesel waste heat recovery and district heating system should proceed. Pursuing the implementation of this project will be a more complex matter than the previous steps. It will first be necessary to retain consultants to address some of the outstanding concerns. Specifically, soils investigations will be required, and further consideration of the necessary end user components for the system should be accomplished. These technical matters, however, will not entail a great deal of work. The more substantial effort will involve coordination of the project, resolution of the various institutional problems and relationships which currently exist, and obtaining financing for the project. The latter efforts will entail seeking the cooperation of several Federal and Yukon government departments as well as private interests in Beaver Creek. Agreeable means for recovering system costs from connected consumers over the life of the project must be determined which means that appropriate pricing mechanisms must be devised. Once these matters are settled, it will probably be necessary to obtain certain energy purchase agreements to support the financing of the project.

   Based on the analysis conducted in this study, the capital cost of this system would be close to $300,000 while the net energy savings would be over $50,000 per year. With a 15-year project life and a 10 percent discount rate, the present value of these savings is about $400,000 and the benefit/cost ratio is 1.3.

The ratio is as low as it is because it is assumed that previously implemented conservation and alternative supply projects are successful. If this assumption does not materialize, the economics of the waste heat system will of course be influenced.

8. The energy plan consortium should undertake an information dissemination program and should assist where it can to ensure that future development in all Yukon communities will incorporate building orientations and designs which will increase substantially the passive solar capabilities of the structures. Such an effort will entail very little cost and will provide substantial benefits for the future. As well, any future buildings should be designed for the Yukon climate with appropriate insulation levels and air tightness standards; the new Forest Service building in Beaver Creek is a good example. On the other hand, the new Customs Building is one of the worst in Yukon in terms of energy conservation.

5.4 Implementation Schedule and Cash Flows

The schedule for activities is somewhat arbitrary as it is dependent on the priorities given implementation by the responsible parties. However, the plan described above can be accomplished in a relatively short time frame. Figure 5-1 provides a possible implementation schedule assuming diligent pursuit of the activities. The figure also summarizes the net cash inflows and outflows if all of the steps described in the previous section are undertaken. Table 5-1 provides more details of these cash flows.

BEAVER CREEK COMMUNITY ENERGY PLAN IMPLEMENTATION SCHEDULE

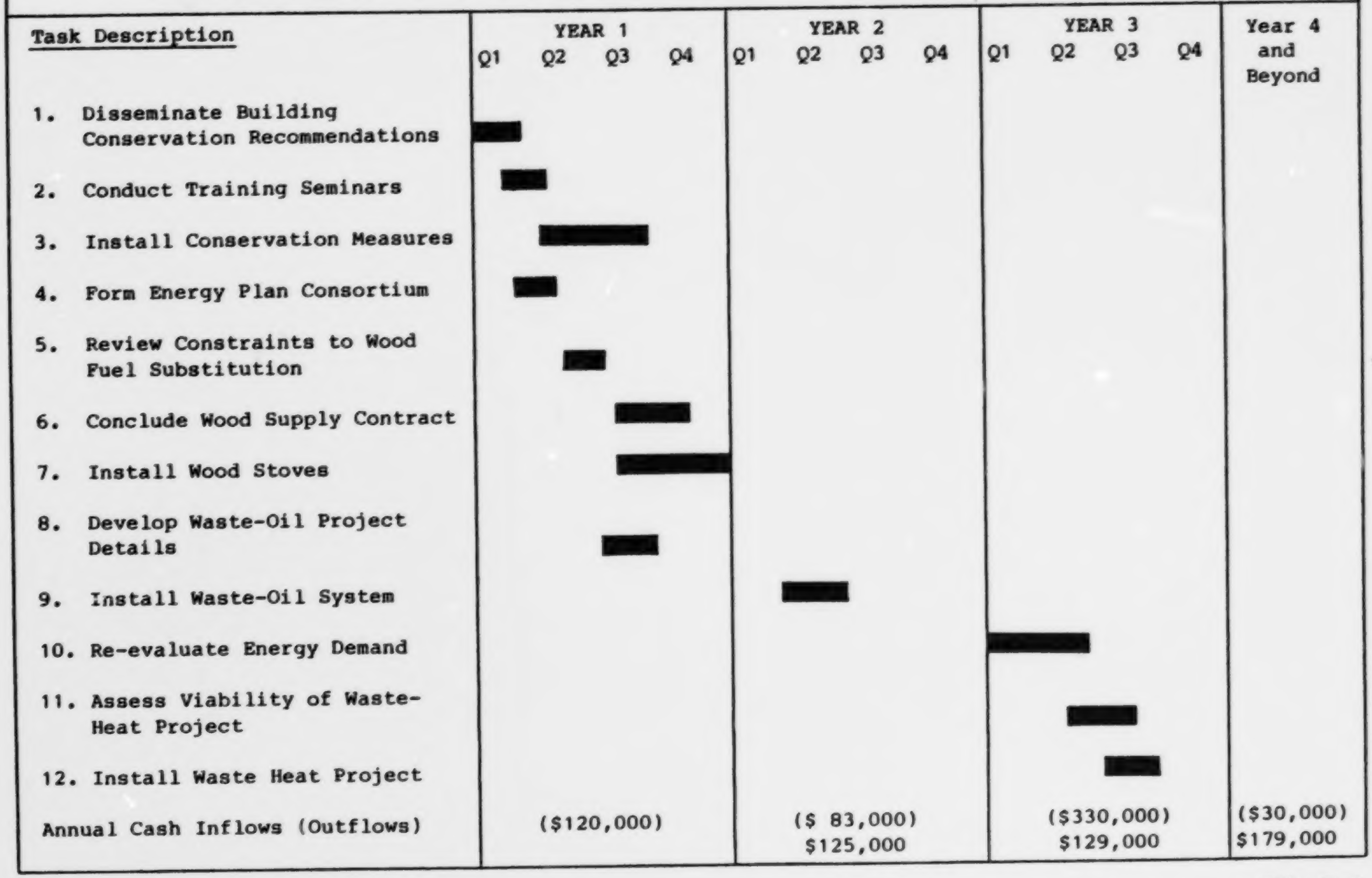


FIG. 5-1

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TABLE 5-1

BEAVER CREEK COMMUNITY
ENERGY PLAN
CASH FLOW SCHEDULE

Year 1	Install Conservation Measures	($120,000)
Year 2	Install Wood Stoves	(42,000)
	Wood Fuel Costs	(30,000)
	Install Waste-Oil Furnace	(11,000)
	Oil Savings Due to Conservation	75,000
	Oil Savings Due to Wood Burning	50,000
	Net	$ 42,000
Year 3	Install Waste-Heat System	(300,000)
	Wood Fuel Costs	(30,000)
	Oil Savings Due to Conservation	75,000
	Oil Savings Due to Wood Burning	50,000
	Oil Savings Due to Waste-Oil	4,000
	Net	($201,000)
Year 4 and Subsequent Years	Wood Fuel Costs	(30,000)
	Oil Savings Due to Conservation	75,000
	Oil Savings Due to Waste Burning	50,000
	Oil Savings Due to Waste Oil	4,000
	Oil Savings Due to Waste Heat	50,000
	Net	$149,000

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PART 2

ENERGY PLANNING HANDBOOK FOR REMOTE NORTHERN COMMUNITIES

To the reader:

Before you turn the page, please consider the following questions:

- Are you interested in promoting job opportunities in your community?
- Are you interested in increasing business profits in your community?
- Are you interested in encouraging a broader economic base in your community?

If your answer to one or more of these questions is "Yes", then you will benefit from the information in this Handbook.

The information in this book represents the efforts of one northern community, a study team composed of two experienced consulting firms, and the Federal and Territorial Governments, to develop a ten step procedure which can be used as a guide to secure the energy future of any northern community.

The Handbook on Energy Planning places strong emphasis on individual and community benefits, and presents energy planning as one method of achieving the three main benefits described above.

WHY COMMUNITY ENERGY PLANNING?

Planning involves making decisions today with an interest and a concern for the future. In terms of energy planning, the principal concerns are cost and availability of future energy resources to support a community.

Although the "energy" component is a relatively new concept to the process of community planning, there are several reasons why a community may decide that it would like to implement an "energy planning" strategy.

The following factors play a major role in directing a community toward energy planning.

a) the present cost of fuel and electricity used for community facilities;

b) uncertainty regarding the economics of future energy supply;

c) the need for additional residential or commercial, or community facilities;

d) the need for upgrading or replacing existing facilities.

It is becoming increasingly more expensive to provide comfortable shelter from the harsh northern winters. The major impetus for energy planning at the community level is to ensure future security of energy supply at reasonable cost. This can be initiated through energy management and energy conservation.

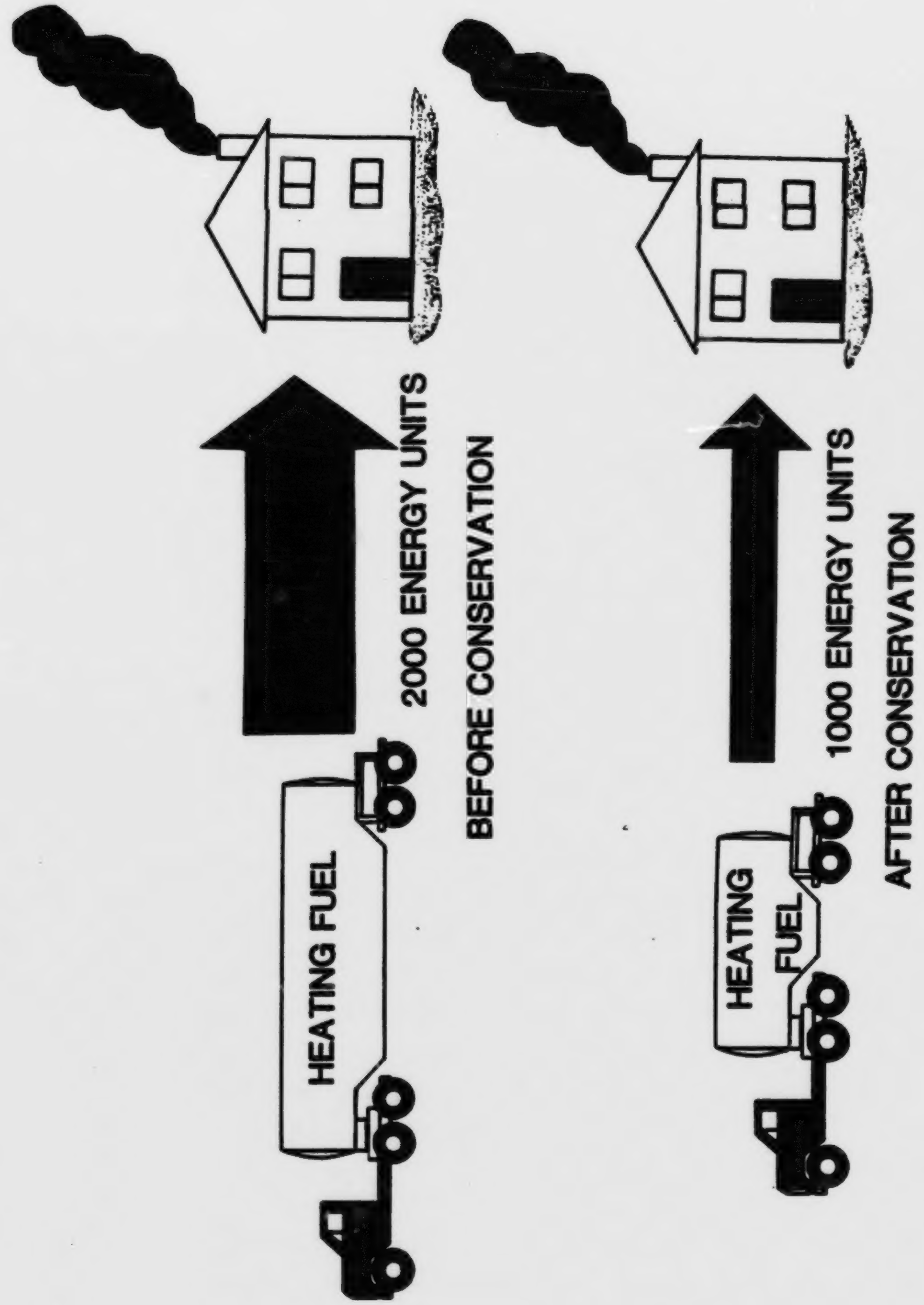
Recognition of the need for better energy management at the administrative or community level can initiate energy planning.

Energy conservation plays the single most important role in reducing the dependency of northern communities on non-renewable energy resources.

From an economic standpoint, three major user groups in any community stand to benefit financially from reducing energy demand: the residential sector, the commercial sector, and the government. Residential users often pay for their own heat and electricity. In commercial operations, energy savings are directly related to operating profits. Energy costs for government buildings are ultimately transferred to the taxpayer.

Reducing high energy costs and developing long term solutions to local energy problems are often the primary reasons for starting the community energy planning process. A well executed energy plan can reduce energy costs in the community as well as encouraging a greater awareness of conservation and resource management in the community as a whole.

The rationale for energy conservation and energy management is very basic. No community can afford


HEATING FUEL
2000 ENERGY UNITS
BEFORE CONSERVATION
HEATING FUEL
1000 ENERGY UNITS
AFTER CONSERVATION

to spend twenty thousand dollars for a new piece of equipment that is only worth ten thousand. In the same way, a community cannot justify using two thousand dollars to heat a building which would only need one thousand dollars worth of energy after conservation measures were applied.

Most small communities in the north are wholly dependent on fossil fuels for heating and generating electricity. These communities were established in the days when oil and gas were cheap and plentiful. Those days are gone.

Planning for a viable future involves many factors. Managing the demand and supply of energy resources is one of those factors. This process is called "energy planning". It involves solving energy problems, and returning benefits to the community.

The benefits of energy planning include saving money, creating local jobs, and keeping more money circulating in the local economy. These benefits are in addition to energy savings. Using local labour and materials to reduce energy demands will decrease the flow of energy dollars to refineries to the south.

One goal of energy planning is to locate energy which is presently wasted in the community, and either reduce it, or put it to better use.

The energy planning process can be incorporated into the existing framework of community planning, or it can be developed as a program on its own. Either way, it includes specific goals and objectives to reduce energy consumption, as well as operating and maintenance costs.

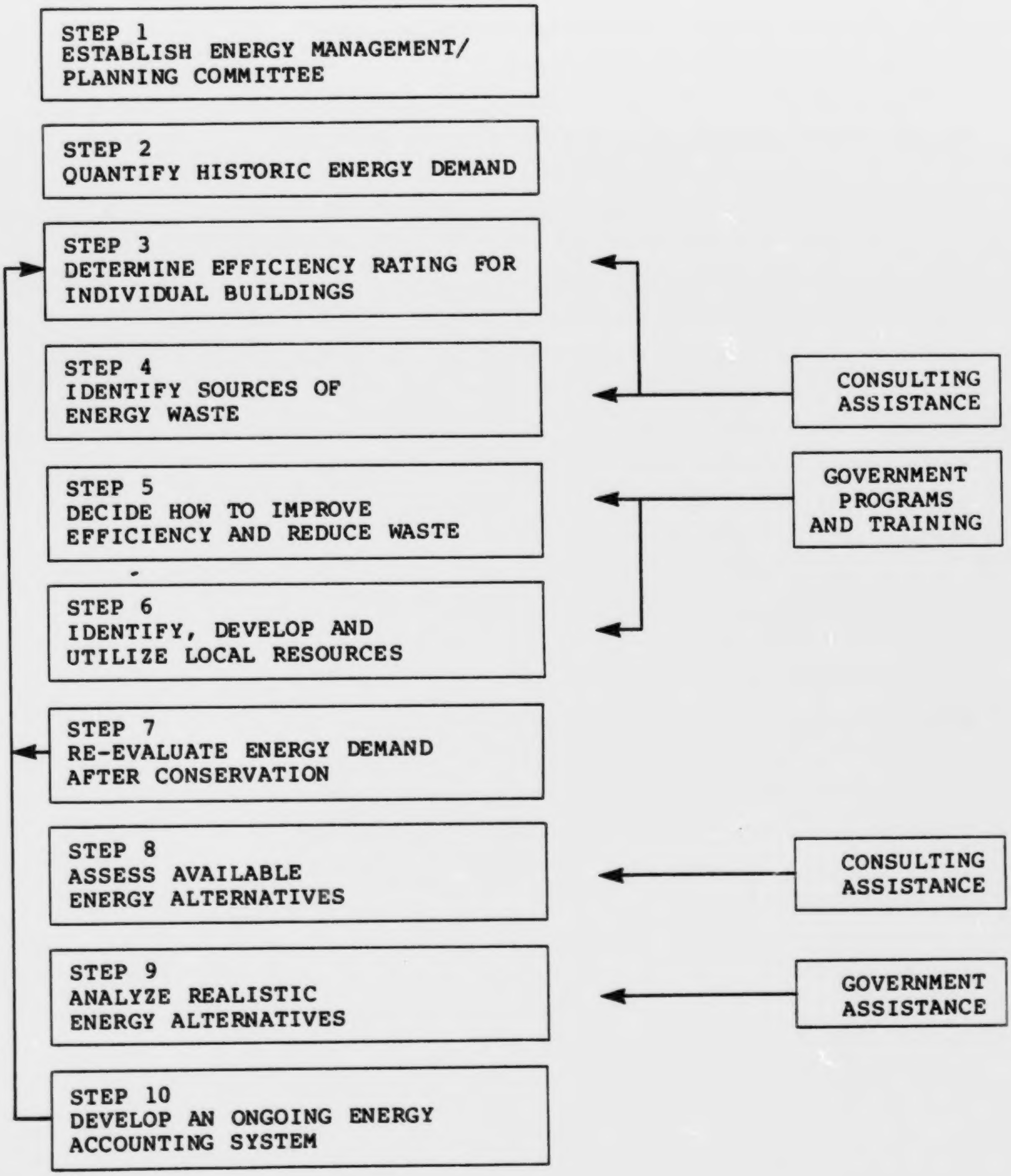
This handbook describes a Ten Step procedure for community energy planning. These steps have been developed to guide any community through the process of energy planning. While all of the basic steps are very important, they serve only as an outline of how a planning committee might proceed.

The Figure on the next page provides a flow diagram of the planning process and highlights each of the Ten Planning Steps which are discussed individually in this Handbook.

All of the work involved in these ten energy planning steps need not be undertaken by the planning committee. There are several routes which a community can take for advice or assistance. The government and private consultants are available to provide experienced assessment of the process at any stage of its development.

To a great extent, the success of any energy planning project depends on individual initiative and enthusiasm and the resources which are utilized. Working with energy management professionals and individuals from other communities who have embarked upon similar projects can be enormously helpful.

TEN STEPS TO COMMUNITY ENERGY PLANNING


STEP 1
ESTABLISH ENERGY MANAGEMENT/ PLANNING COMMITTEE
STEP 2
QUANTIFY HISTORIC ENERGY DEMAND
STEP 3
DETERMINE EFFICIENCY RATING FOR INDIVIDUAL BUILDINGS
STEP 4
IDENTIFY SOURCES OF ENERGY WASTE
STEP 5
DECIDE HOW TO IMPROVE EFFICIENCY AND REDUCE WASTE
STEP 6
IDENTIFY, DEVELOP AND UTILIZE LOCAL RESOURCES
STEP 7
RE-EVALUATE ENERGY DEMAND AFTER CONSERVATION
STEP 8
ASSESS AVAILABLE ENERGY ALTERNATIVES
STEP 9
ANALYZE REALISTIC ENERGY ALTERNATIVES
STEP 10
DEVELOP AN ONGOING ENERGY ACCOUNTING SYSTEM
CONSULTING ASSISTANCE
GOVERNMENT PROGRAMS AND TRAINING
CONSULTING ASSISTANCE
GOVERNMENT ASSISTANCE

STEP 1: ESTABLISH AN ENERGY PLANNING COMMITTEE

An organized community Energy Planning Committee is necessary for the success of an energy planning program. The purpose of the committee is to provide guidance and continuity throughout the program, and provide a core group for discussion and liaison with the government, consultants and other communities.

The forming of the committee itself can be an important first step in evaluating the community's energy priorities. The group will likely be composed of those who are most concerned with energy problems and will probably represent the key areas, and the overall interest, in energy planning in the community.

There are often advantages to initiating the energy planning process within the framework of an existing administrative organization, such as a Chamber of Commerce, a Band Council, or a Community Club. Organizations like these contribute to the sense of permanence in the community, an essential ingredient for successful program.

WHO SHOULD BE INVOLVED?

The people who make up the population of each community are unique. Therefore, the people who sit on the planning committee will vary from one community to the next.

A successful committee will represent a wide cross-section of the community. A strong committee could include:

- community leaders
- government representatives
- band council members
- utility company representatives
- commercial operators and business people
- homeowners

WHAT DOES THE COMMITTEE DO?

The primary function of the energy planning committee is to co-ordinate the planning process through liaison with the government and consulting experts hired by the community. Through this liaison, the energy planning committee can administer training programs for local personnel, supervise project implementation, and develop an ongoing energy accounting system to monitor long-term energy savings.

In the early stages of the planning process, the committee may also wish to locate experienced consultants or local resource people to provide information, training and data management expertise.

The energy planning committee may also wish to organize the presentation of seminars and workshops on energy conservation and energy management for members of the community. Such workshops provide the opportunity to utilize the capabilities of a variety of resource people, including government representatives and other energy experts. This will help the committee to determine how they can use the services of these people to provide further assistance to the energy planning process.

Energy conservation and energy management opportunities vary greatly from sector to sector in any community. Government programs are usually directed toward one specific "energy user" group, such as commercial or business facilities, or residential dwellings. The energy planning committee may wish to identify specific individuals on the committee who will be responsible for obtaining information on government programs available to a specific energy use sector in the community.

During its first meetings, the energy planning committee may discuss and identify specific energy problems which need to be solved, and investigate available government and technical assistance for this purpose.

Both the Federal and Territorial governments offer energy conservation grants or other types of funding which may be applicable to the community. Programs such as these should be reviewed periodically, as their availability may change.

The Government can also provide a wealth of literature and publications on energy related programs and technology. The energy planning committee can contact government personnel who can provide information on the availability and application of specific programs.

Each sector in the community has different opportunities and benefits to gain from energy conservation and energy management. Specific government programs are directed toward specific sectors. Utilizing these programs may provide additional benefits to the recipients within certain sectors.

Residential users and commercial or business operators may choose to participate actively in the energy planning process. The energy planning committee can co-ordinate the availability of information on specific energy saving opportunities and programs to these sectors through workshops and seminars. However, the involvement of these groups is based on individual initiative; therefore, the benefits which they gain will reflect the extent of their involvement.

STEP 2: QUANTIFY HISTORIC ENERGY DEMAND

The next step in the planning process is to determine how much energy is used in the community at the present time. Clearly, it will not be practical to develop measures for changing energy consumption patterns without knowing what they are in the first place.

In many ways, energy planning is like financial planning. In order to achieve their objectives, fiscally, communities assess their resources, establish priorities and budget their expenditures. They then keep track of where they are and where they are going with an accounting system. The accounting system provides critical decision-making information to managers and it constitutes a means of "keeping score", by documenting what has happened.

An energy accounting system is as critical to the energy planning process as the financial accounting system is to the budgeting process.

A number of key questions must be addressed to this stage:

- What kinds of energy are used for heating?
- What kinds of energy are used for generating electricity?
- What kinds of energy are used for hot water?
- How much is used in each building?

- How much of each is used in the whole community?
- How much does the energy cost?

In most northern communities the answers to these questions will indicate that the two most significant areas of energy consumption and expenditure are for:

- space heating (with heating oil and wood); and,
- electric generation (with diesel fuel for operating lights, appliances and hot water heaters).

Fuel and electrical bills are an important part of the necessary information. Energy bills for the previous twelve months (at least) are collected for each building, and an "annual consumption" is calculated for electricity (in kilowatt hours), and for fuel (in litres). These figures can then be converted to energy units to provide a basis for further analysis.

Although the entire population may not be participating actively in the energy planning process, it is valuable to assess the historic energy use of every building in the community. The assessment will provide a clear picture of total energy use for the community. This picture will be very useful in determining which buildings could benefit from energy conservation or upgraded energy management procedures. A building operator may become more interested in energy planning if he/

she can see the value of the benefits which will be returned directly to them.

The energy planning committee may wish to retain the services of a consulting team to assist with the analysis. The most time-consuming part of this analysis, however, is the gathering the energy records. If the energy bills for each building can be assembled by the committee, it will significantly reduce the amount of work for the consulting team.

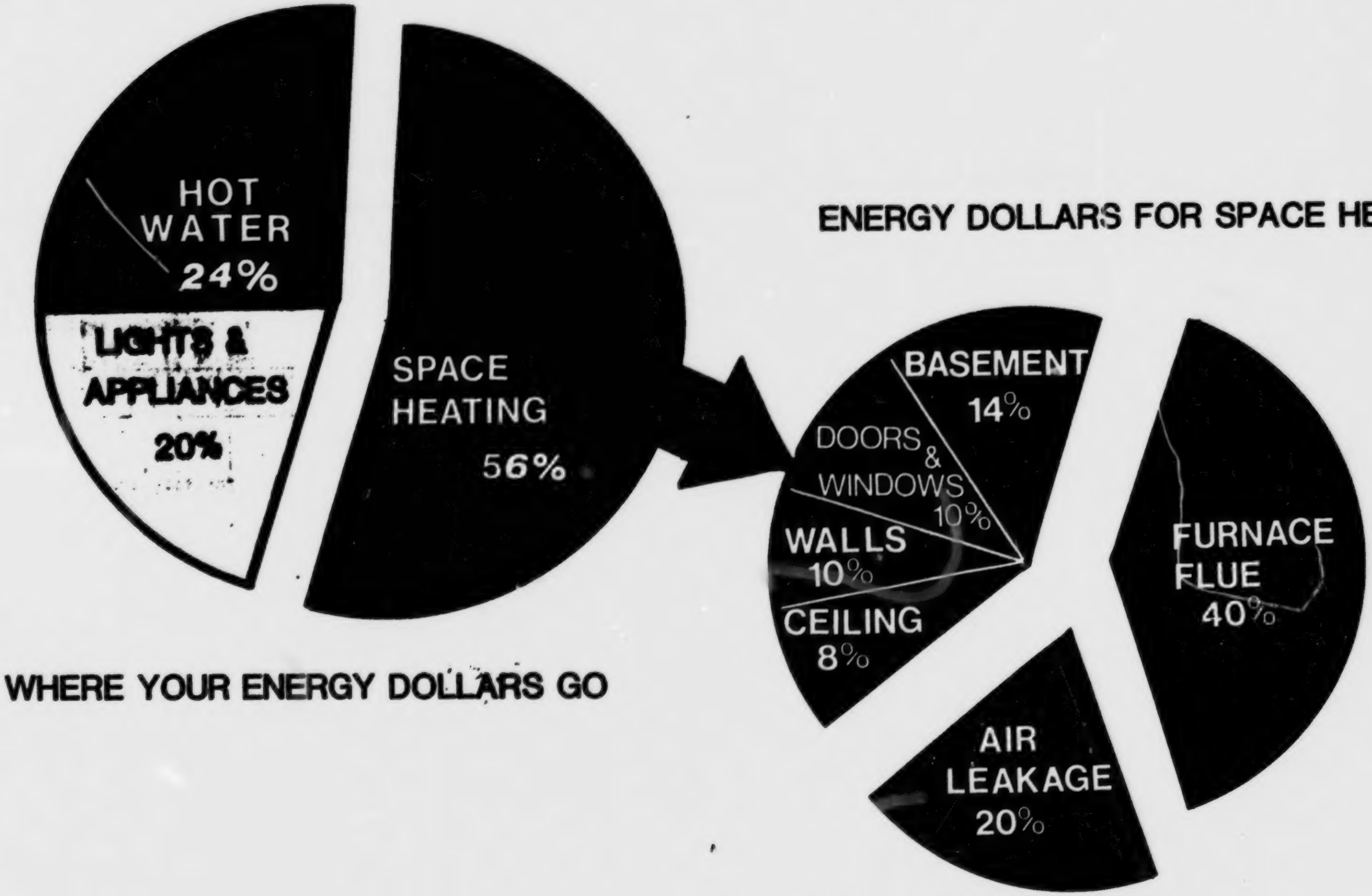
STEP 3: DETERMINE EFFICIENCY RATING FOR INDIVIDUAL BUILDINGS

In the same way that cars have an efficiency rating measured in litres per hundred kilometres, each building has a unique "energy demand" or "energy use" rating. This rating represents the space heating efficiency of the building.

WHAT IS ENERGY DEMAND?

Energy demand is the amount of energy required by a building and its occupants to maintain a comfortable interior environment. The results of surveys and analyses of many northern buildings have shown that energy demands are primarily for space heating and for domestic or service hot water. Electricity used for lighting and appliances usually contributes to the space heating demand. However, electricity used for outside lighting, water pumping or freeze protection heat tracing must be factored out and analyzed separately.

The energy performance rating can be calculated using energy bills, building size, and climate records. This provides a rating of the amount of energy used to heat a volume of space for every degree of "coldness" outside. The rating is often expressed in "Kilojoules per cubic metre per degree day" ($kj/m^3/DD$).



WHERE YOUR ENERGY DOLLARS GO

ENERGY DOLLARS FOR SPACE HEATING

Because the energy performance rating compensates for building size and local climate, it becomes an effective index for comparing individual buildings. In addition, the performance rating will show any changes in building operating efficiency as a result of conservation, or other factors which affect energy use.

The other significant parameter of building energy demand is the consumption of domestic hot water (DHW). This factor is less dependent on the characteristics of the building and more dependant on the efficiency of the hot water system and lifestyle particulars of the building occupants. A useful way to rate DHW demand is in terms of kWh per day or megajoules per day.

WHY ARE DEMAND AND PERFORMANCE RATINGS IMPORTANT?

The energy performance ratings or "indices" are an important factor in the energy planning process. Since the index compensates for building size and outside temperature, it can be used to compare energy use efficiency among a group of buildings. It can be used to rank the buildings on the basis of efficiency, and to assist the energy planning committee in making decisions on where to begin implementing conservation measures.

As well, the performance index is used to compare the efficiency of a building from year to year, and before and after energy management has been implemented. Without some method of standardizing building performance, it becomes difficult (if not impossible) to tell whether reduced operating costs are a result of energy management changes or simply due to milder weather during a heating season. It is often helpful to compare the operation of two or more buildings with similar functions located in different communities. For example, if one community operates its firehall more efficiently than others, then it has valuable experience to share.

This ranking of buildings by energy use efficiency enables the energy planning committee to proceed with a more detailed assessment of the buildings, starting with the most inefficient buildings first.

STEP 4: IDENTIFY SOURCES OF ENERGY WASTE

An important factor in the community energy planning process is the energy survey of heated buildings. This provides an understanding of total and individual building energy consumption. As well, the surveys provide the basis for evaluating conservation and energy management opportunities.

Building surveys have, as their primary objective the identification of the most serious causes of inefficient energy use which are responsible for energy losses or waste. Energy waste can be found in almost every building, but the most inefficient buildings are the ones where the waste and the potential for energy savings are the greatest. The detailed surveys provide the means for documenting what should be done and what energy savings can be achieved.

WHAT IS AN ENERGY SURVEY?

An energy survey consists of on-site data collection, and discussions with building occupants to identify operating and maintenance problems. The surveyors watch for signs and symptoms of energy waste, and identify these areas in their recommendations. The recommendations detail conservation measures which will save energy and money, and increase comfort to the occupants.

The purpose of an energy survey is to discover how much energy goes to each part of the building.

The method used to analyse the building can determine where the energy goes (i.e., through walls, windows, air leaks, heating system stack losses), and how much goes to each area. Each part of the building is analyzed to determine its consumption in energy units and dollars per year.

The energy performance index described earlier allowed the ranking of many buildings for a management plan. In the same way, the ranking of individual elements in a building (on the basis of yearly energy cost) allows the building owner to most effectively invest time and materials toward energy savings.

Furthermore, the analysis must always check to make sure that predicted energy use agrees with previous electricity and fuel records for each building surveyed. One effective method of analysis computes a building performance index from building survey data and compares this value with a performance index computed from energy records.

The energy survey and analysis provides a complete understanding of individual building energy consumption. In addition, the survey analysis identifies the factors which could contribute to potential savings for individual buildings. This provides the basis for estimating the cost of energy conservation, and energy management strategies for each building.

WHAT ARE SOME EXAMPLES OF ENERGY WASTE?

Many recurrent building maintenance problems are directly related to energy waste, and can often be permanently solved by a few energy conservation improvements and improved energy management strategies.

For example, frost accumulations under the eaves and at attic vents, peeling paint, mildew, water stains on ceilings and walls, poorly fitting doors and windows and shifting foundations can all indicate energy waste. These are also common problems which can put a strain on building maintenance budgets.

Most northern buildings lose excessive amounts of energy through air leaks in the building shell (or "envelope"), and inefficiencies in the heating and hot water supply systems.

Since these two areas have the highest energy costs, they are the best targets for energy conservation.

STEP 5: DECIDE HOW TO IMPROVE EFFICIENCY AND REDUCE ENERGY WASTE

The first main benefit of energy planning is to save money. Conservation can turn energy waste into dollar savings by improving energy use in the buildings. It does not mean going without, it simply means using existing energy resources more efficiently.

The results of the energy survey analyses produce specific energy conservation recommendations for each building. Recommendations include improvements such as: air leak sealing, adding insulation, and efficiency upgrading of the heating system. These recommendations can be reviewed with the building owners or occupants to develop a plan for implementing conservation measures.

WHAT ARE THE ECONOMIC IMPLICATIONS OF REDUCING ENERGY WASTE THROUGH CONSERVATION?

The economics of energy conservation are fairly straightforward. Generally, a conservation project entails some initial cost for implementation, followed by a stream of benefits in the form of energy savings over future years. The amount of the benefits is the difference between estimated energy consumption before implementation of the project and the estimated consumption after upgrading.

For each potential project, an assessment must be conducted to determine whether the energy savings (converted to dollars), justify the initial costs. This exercise is referred to as "life cycle costing". The following simple example illustrates the analysis:

Assume a water heating system can be upgraded by insulating the tank and pipes at an initial cost of $400. Current consumption of this system is 5,000 kWh per year and the electricty costs 15¢/kWh, or $750 per year. After insulation estimated consumption will be 3000 kWh, or $450. Thus, the annual savings will be $300. If this water heating system is to be used for two more years, then the total benefit arising from the initial investment of $400 will be $600. These values can be reduced to a benefit/cost ratio simply by dividing the $600 by $400. This ratio is 1.5 and can be interpreted as indicating that for each dollar invested in this project, the return will be $1.50. This type of analysis provides a means for determining which projects are most attractive and what priorities should be placed on these projects.

(Note: For more complicated projects where changes in operating and maintenance costs are anticipated, or project benefits are expected to span longer time periods, or inflation is expected to change the values of future benefits, it is necessary to employ more sophisticated techniques for evaluating projects. Specifically, all dollar estimates should be "discounted" to allow for the fact that future dollars are less valuable than dollars in hand today.)

It should be recognized that there may be other benefits associated with conservation projects in addition to saving energy and money. Increased comfort to the occupants of the building or increased security of supply may be applicable. It is important to consider these factors as well.

Once the economics of a conservation measure have been identified, the energy planning committee can rank projects on the basis of cost-effectiveness and the expected energy savings. Detailed designs may then be developed for implementation of conservation options.

WHERE CAN THE GREATEST SAVINGS BE EXPECTED?

Many conservation measures are simple, low in cost, and can be applied successfully on most buildings. The application of conservation measures is generally referred to as "retrofitting".

Caulking and weatherstripping will reduce cold drafts and hot air leaks around doors and windows. Implementing air leak sealing measures alone can markedly reduce the energy needs of a building.

Air sealing and adding insulation, especially in the attic and uninsulated basements or crawl-spaces, will help to keep the heat from escaping. Insulating the uninsulated areas first will make the most significant difference in energy use.

Installing low flow showerheads and insulating hot water tanks and pipes can reduce hot water energy requirements by as much as 50 percent.

To meet the changing needs of consumers. manufacturers are developing new products and materials which are designed specifically to save energy.

For example, the heating industry has introduced setback thermostats, retention head burners, and stack dampers for oil heating systems. With this equipment, the system can achieve a seasonal efficiency as high as 85 percent.

Furnace tuning and servicing will significantly improve the efficiency of oil heating systems. Wood stoves and woodstove operation can often be improved to burn wood more efficiently as well.

In the case of wood buring appliances, inefficiency is directly related to air pollution and chimney fire problems. Newer stoves and furnaces can rival oil fired units in terms of efficiency when operated correctly.

Some buildings are so poorly insulated and air sealed that a "full-wrap-retrofit" is recommended. This involves wrapping all or part of the building with a new vapour barrier and additional insulation. Other buildings may have degraded to the extent that replacement is more practical than repair.

It may be not be economically practical to implement all of the survey recommendations, but the low-cost and no-cost measures will almost always save money and increase comfort.

If conservation is applied to the most inefficient buildings first, the savings will begin to accumulate immediately.

STEP 6: IDENTIFY, DEVELOP AND UTILIZE LOCAL RESOURCES

Another main benefit of energy planning is to increase the flow of dollars in the community. If local resources are used to implement conservation, the benefits returned to the community will be greater. These resources can include trained local labour and building materials.

WHAT IS THE ROLE OF TRAINING?

There are a few conservation measures which can be effectively implemented by untrained inexperienced individuals. In most cases, implementing energy conservation measures effectively requires skill and experience.

Part of the energy planning process involves training local people in the use of energy saving materials and techniques. With trained local expertise, more labour dollars will stay in the community.

Hundreds of energy saving designs, products, and services are available. However, only some of these are effective and reliable in the north. Training includes the selection and use of appropriate materials and techniques.

Many northern communities are coming to realize the importance of local expertise in energy conserving practices. These communities are actively involved in training programs for local people to provide guidance and advice on energy conservation and management decisions.

HOW CAN THE COMMUNITY USE TRAINED LOCAL LABOUR?

The third main benefit of energy planning is to create local jobs.

The energy planning committee will need to contract or employ trained people to implement energy conservation measures. With trained experts at the community level, the energy planning committee can hire local people for this work.

Trained personnel can provide services in developing suitable designs for energy retrofit projects, installing energy saving materials and equipment, and providing assistance and instructions in the use of energy saving equipment and facilities.

Training programs can be effectively combined with the implementation of energy conservation measures for community buildings. For example, a crew of local carpenters can be trained in many appropriate techniques of energy conserving construction using the retrofit of a community building as a "hands-on" training project.

WHAT OTHER LOCAL RESOURCES CAN BE USED?

Where local materials can be used in energy conservation projects, the economic benefits to the community are even greater. Local materials can include products sold by local suppliers, as well as materials which are locally produced. For example, since most of the lumber used in a full retrofit is not structural, locally milled, ungraded lumber can be used.

Government assistance may frequently be available to pay for a portion of the energy conservation measures. The energy planning committee can check with government representatives to find out how to apply for such assistance.

STEP 7: RE-EVALUATE ENERGY DEMAND AFTER CONSERVATION

If the buildings which waste the most energy are the first targets for conservation, then the energy use for those buildings can drop dramatically following the improvements. If these improvements are started in the spring and completed in the fall, the drop in energy use can be seen between the previous winter and the coming winter.

As more and more conservation projects are completed, it can be expected that the total energy demand of the entire community will decrease. The buildings in the community are now more "energy efficient".

The Building Performance Index as discussed above provides an effective means of determining the impact of conservation measures. The index is recalculated after conservation to provide an accurate measure of energy savings which is independent of "mild" or "harsh" winters.

At the same time, this new performance index is a measure of the new energy demand of the building, and can then be used to correctly size an alternative energy system or to downsize the existing system for better operating efficiency.

HOW DOES REDUCED DEMAND AFFECT ENERGY ALTERNATIVES?

The method for "sizing" suitable alternative energy supply systems is based on the energy demand. This is true for individual buildings or for the entire community. A realistic evaluation of energy demand is an important step in this process of matching any new system to meet individual building or community energy needs.

The efficiency of an alternative energy supply system for a community depends on how well the system is matched to the energy demand of the building. This requires a thorough understanding of the post-conservation energy demands, peak demands and the differences in technical efficiency of alternative supply systems.

Once conservation measures are in place and the new energy demand has been identified, the community can assess the potential of alternative energy supplies for individual buildings, or for groups of buildings in the community.

These energy supply and energy demand principles become even more critical when sizing energy systems to supply a group of buildings, as such systems may cost hundreds of thousands of dollars.

By using a system of continuously evaluating the Building Performance Index, the energy planning committee can develop a simple energy accounting procedure for monitoring changes in energy use for each building. This procedure would allow the energy planning committee to re-evaluate energy demand on a building-by-building basis, or in a larger picture of the entire community.

As the implementation of energy conservation continues, the rate of decreasing energy demand (as shown by the energy accounting summary) will change. The records will begin to show that the decrease in community energy demand is slowing down. On the buildings which didn't need conservation as much as others, the energy conservation measures have a lower cost/benefit ratio.

The energy planning committee can expect that this will occur, and be watching for it in the energy accounting summary. When it happens, it is time for the energy planning committee to re-evaluate the energy plan, and proceed with the next step. However, community conservation is applied to most community buildings and a new, reduced energy demand is established.

STEP 8: ASSESS AVAILABLE ENERGY ALTERNATIVES

After the energy demand in the community has been reduced through conservation, the next step is to consider providing an alternative (or supplementary) energy supply, or increasing the efficiency of the present supply.

There are several technically proven and economically attractive alternatives for heating buildings and producing electricity. Oil furnaces and diesel generators need not have a monopoly on the future supply and delivery of energy in the north.

Some alternatives merit consideration in any community. Not all of them will be appropriate, and perhaps none will make sense in some communities. The analysis of feasible alternatives can be complex. However, there is expert advice and assistance available from the Regional Governments, the Federal Government, and private consulting professionals.

Because supply alternatives involve the entire community, planning and co-operation are required. The planning process for alternative energy use is not always a simple straightforward endeavor. It takes time and dedicated effort to identify which alternatives, if any, are appropriate. However, these efforts will pay off.

Energy supply alternatives may be readily available in the community, and do not necessarily involve elaborate technologies. The following examples show two possible alternative energy sources which simply utilize an existing waste resource to provide energy.

Example 1:

In some communities, thousands of litres of used crankcase oil, transmission fluids, and other oils from several local sources are hauled away for disposal each year.

It costs money to haul these wastes away, yet they can be burned efficiently in specially designed furnaces to provide heat for community buildings. With existing technology, this waste disposal problem can become a significant energy solution.

Example 2:

Many northern communities are dependant upon diesel generators for their electrical power. Diesel engines can, at best, only convert about 30 percent of the fuel they burn into electricity. The remaining 70 percent of the energy is dissipated to the environment as heat up the exhaust stack or through the radiator.

This unused energy is called "waste heat". Recent increases in the cost of fuel oil have provided the incentive to capture waste heat and distribute it to community buildings through a district heating system.

If oil-heated buildings in a community can use this waste heat, literally thousands of dollars presently spent on heating fuel can be saved.

HOW CAN ALTERNATIVES BE COMPARED?

Once the energy demand of the community has been estimated and the appropriate conservation opportunities available to the community have been implemented, there may still be a substantial requirement for energy. Even after conservation, these demands can represent significant expenditures for the community.

For the most part, a large portion of these remaining energy needs will still be supplied by oil in northern communities. Diesel fuel will be the primary source of electric generation in those communities not connected to the hydroelectric grid. Fuel oil and wood will be the chief sources of space heat.

From the energy surveys and energy demand assessment completed in earlier stages of the energy planning process, an estimate of the volume of oil being used to meet each of these demands should be available. In considering alternative sources of energy, it is convenient to convert the energy requirements into common units so that alternatives can be compared directly. Otherwise, it is difficult to determine whether it more cost-effective to consume a thousand litres of oil or 20 cords of wood. Each source of fuel however, has an energy content which can be expressed in common units to allow direct comparison.

For example, for preliminary planning purposes, it can be assumed that a litre of diesel or heating oil contains 38 MJ of energy, one kilowatt hour of electrical energy represents 3.6 MJ, and a cord of wood contains 18,000 MJ, or 18 GJ. The table on the following page summarizes the gross energy content of typical conventional fuels. Note that in the column "Typical Conversion Efficiency" the technical ability to extract energy from these fuels varies according to application and technology. Thus, when considering substitution of conventional fuels with alternatives, it is necessary to supply the net energy after conversion to satisfy the demand. Depending upon the conversion efficiency of the technology, the input energy can be greater or less than that supplied by the current fuel.

Recognition of these conversion efficiencies is also important when determining the costs of various energy alternatives. An example of this can be shown in the case of diesel generation. If it is assumed that a litre of diesel oil costs 45¢, and the conversion efficiency is 30 percent, then the usable energy from the generator will be 3.1 kWh/litre. To determine the fuel component cost per kWh, simply divide the 45¢ by 3.1, which yields a cost per kWh of 14.5¢. The same manipulation can be made for other energy types to arrive at a cost per net unit of energy.

ENERGY CONTENT of TYPICAL FUELS AND CONVERSIONS

Energy Type	Gross Energy Content	Conversion Efficiency (%)	Net Energy Yield
Heating Oil	38 MJ/litre	65 (furnace)	22.8 MJ
		45 (pot burner)	11.4 MJ
Diesel Fuel	38 MJ/litre	30	11.4 MJ (3.1 kWh)
Wood	18 GJ/cord	10 (fireplace)	1.8 GJ
		50/70 (air tight stove)	9-12.6 GJ
		60 (chip-fired boiler)	10.8 GJ
Propane	25.5 MJ/litre	70	17.8 MJ
Hydro Power	3.6 MJ/kWh	100	3.6 MJ

When considering alternative energy sources, it is first necessary to identify potential energy resources. Bascially, this involves consideration of a number of questions such as: are there large streams decending over significant elevations in the area? Is the area generally windy? Are large supplies of fuel wood nearby and accessable? Are there natural hot springs near by?

The answers to these and similar questions will begin to help Energy Planning Committee focus on those alternatives which are more likely to be feasible in their locale. The whole question of energy supply, demand, and alternatives can be exceedingly subtle. Eventual solutions will be dictated by technological factors, natural phenomena, economic considerations and individual consumer attitudes. There is no straightforward path or simple checklist for determining the optimum energy system for even a single building, let alone an entire community. The Energy Planning Committee must be conscious of the range of complexities through each step of the planning process, recognizing that virtually all solutions will involve tradeoffs between competing demands and constraints.

STEP 9: ANALYZE REALISTIC ENERGY ALTERNATIVES

WHAT SOURCES SHOULD BE INVESTIGATED?

The following sub-sections describe the essential technical criteria for a variety of alternative energy technologies which may be appropriate to the north. These criteria will assist planners in determining whether a particular alternative energy project might be pursued in the community. The criteria listed in this section will allow a preliminary screening of the possible options.

- Wood Resources
- Diesel Waste Heat Recovery
- Waste Oil Recovery
- Solar Energy
- Hydroelectric Power
- Wind Energy
- Peat Energy Resource
- Geothermal Power
- Biogas Energy Systems

Wood Resources

To use wood as a significant source of energy in the community, there must be an ample supply of suitable timber relatively near the community and accessible by vehicles. In some areas, fire-killed stands represent an excellent source of fuel wood. In the other areas, "green" timber can also be used. In either case, the long-term sustainable yield must be considered. It is not appropriate to spend a great deal of money for a wood chipper and wood fired boiler when the supply of wood could run out in a few years. Some assessment of the volume of wood available from the harvesting area must be made and an estimate of the rate of harvesting and the rate of natural replacement must be considered. If a forested area is harvested at a rate of 5 percent, and the natural growth for northern species is 0.5 percent, then the fuel supply will be exhausted in 22 years. It would then take 200 years for that forested area to reestablish itself.

Wood resources are relatively abundant at many remote communities. Wood can be used in a number of ways including the generation of steam for process heating and the cogeneration of electricity, direct heating or the firing of water tanks or water boilers for space heating and water heating, and gasification. Wood is already widely used primarily as a source of direct heat from combusion in fireplaces, wood stoves and airtight furnaces.

The energy content of a volume of wood varies with the density of the fuel and the moisture content. Since tree growth in the north is relatively slow, the resulting wood tends to be denser than timber stands found further south. If the wood supply is from a fire killed stand, moisture content can be quite low (i.e. 10 percent) and the energy content can be as much as 18 gigajoules per cord (2.26 cubic meters). For green timber, the moisture content is much higher. This moisture reduces efficiency of the wood-burner, since more of the heat energy is required to vaporize the water, leaving less energy for space heating.

The technology for using wood is relatively straightforward and well-proven. Airtight wood stoves represent the most common application, and are suitable for use in most residential and smaller commercial buildings as a source of space heat. Typical efficiency of such systems is about 55%, which means between 9 and 10 GJ of usable energy are supplied by a cord. At costs of between $75 and $100 per cord, the resulting fuel cost per GJ of net energy is $7.90 to $10.50. This compares with a net cost of close to $17 per GJ for oil with 65% furnace efficiency. While wood is much less convenient to use than oil, it is clear that the favourable economics are encouraging more and more wood use. Installed costs for wood burners range from $1,200 to $1,500 for typical residential units. Wood burners can also be fitted with hot water boilers, thereby using the fuel to supply domestic hot water. Conventional water heaters are still required however, because hot water demand persists during the summer when the wood stove is not required for space heating. Wood stoves are also available which can be used for cooking.

It is probable that the utilization of wood would increase in certain areas through centralized harvesting, truck transport and forest management techniques. Certainly, some consumers would switch to wood if they did not have to obtain it themselves.

An important factor in favour of wood based technologies is the fact that the *harvesting* chipping, delivering, and use of wood resources keeps economic resources within the community and provides local employment. With oil purchases, all except some of the distribution revenue goes out of the region.

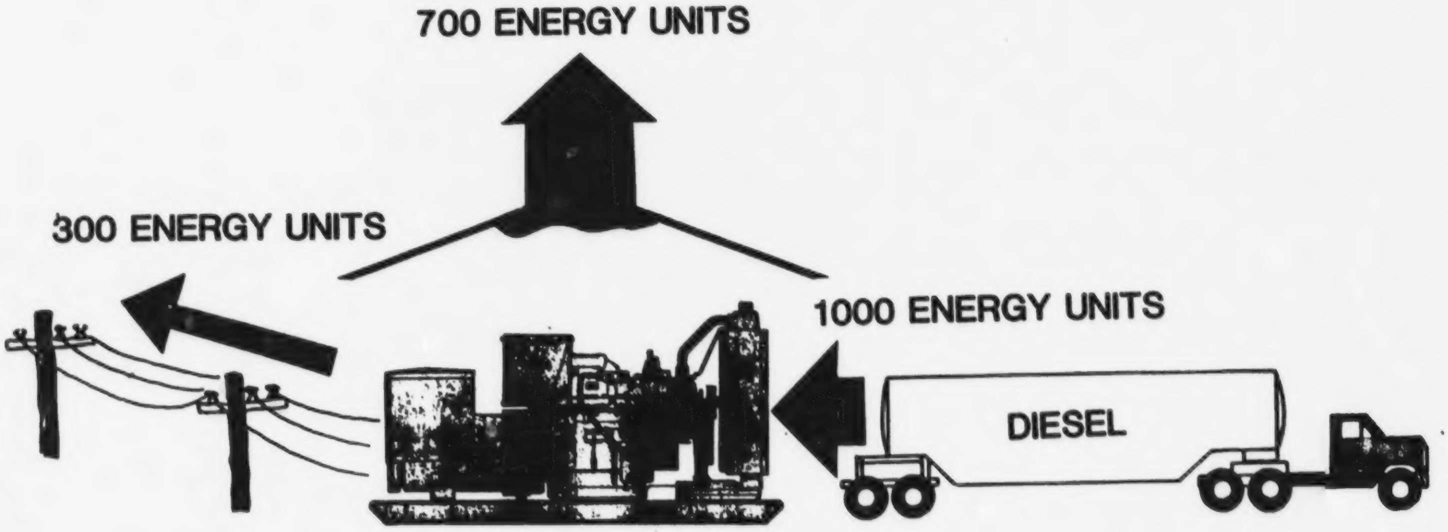
Diesel Waste Heat Recovery

For some communities, diesel generators are the only feasible source of electric power for the forseeable future. Where this is the case, opportunities may exist for better utilizing the energy content of the fuel burned in the diesel engines through waste heat recovery.

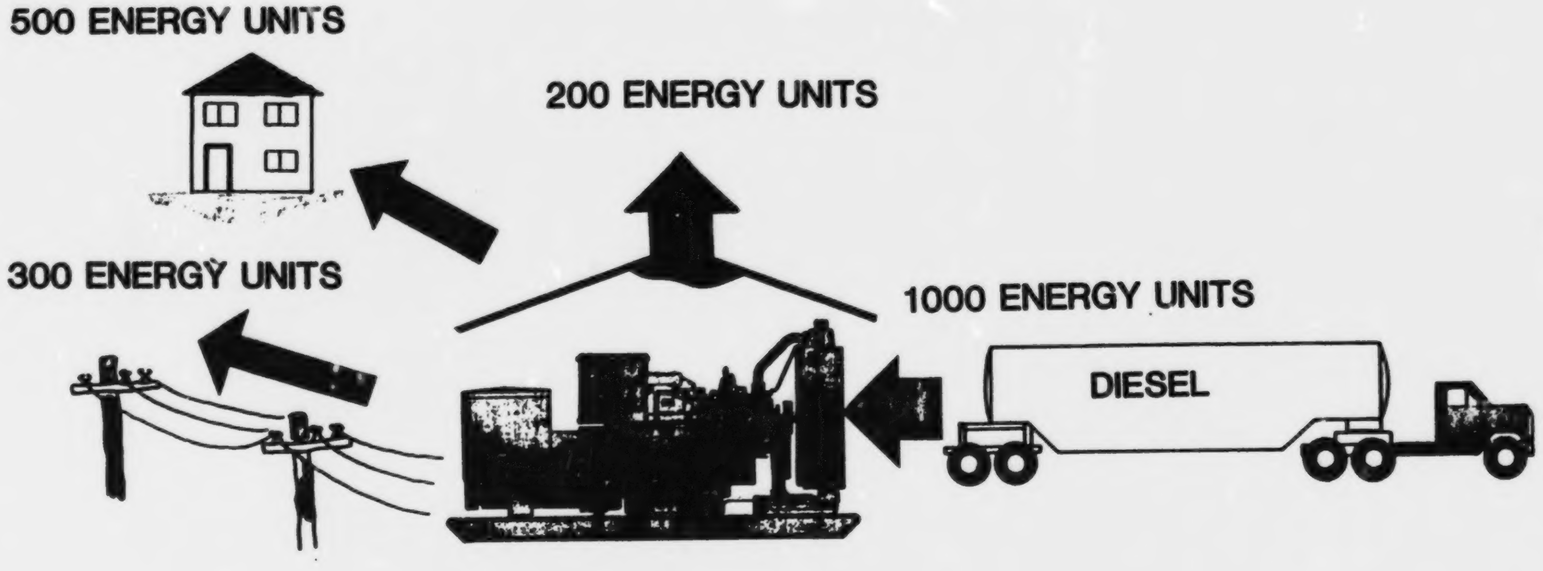
Typically, engines convert only 24% to 33% of the input fuel energy into usable power. In general, the output from a diesel generator is about 3 kWh (10.8 MJ) per litre of fuel (37.65 MJ). The input energy which is not converted to electricity, is transformed into heat. This heat energy is removed from the engine by jacket water cooling, exhaust gases and radiation in the following proportions:

- 30% (10.8 MJ) to the jacket water/radiator;
- 30% (10.8 MJ) to the exhaust;
- 10% - 15% (3.6 MJ to 5.4 MJ) as radiation to the surrounding space.

Almost all of the jacket waste heat and about half of the exhaust waste heat may be recovered. Thus,


700 ENERGY UNITS
300 ENERGY UNITS
1000 ENERGY UNITS
DIESEL

BEFORE DISTRICT HEATING


500 ENERGY UNITS
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300 ENERGY UNITS
1000 ENERGY UNITS
DIESEL

WITH DISTRICT HEATING

the utilization of fuel can be increased to about 75%.

Heat recovery systems are technically simple and straightforward in most cases incorporating readily available system components and materials. Heat exchange units transfer jacket and exhaust heat to a district heating loop. The heated water in this loop is pumped through insulated pipe. After giving up heat energy through heating coils in the end-user's building, the cooled water circulates back to the central heating plant for recharging. Many mechanical engineering or heating/ventilation/air-conditioning (HVAC) consultants would be qualified to design the actual system.

If your community has a diesel generator then consult the appendix for more information on evaluating the feasibility of using this resource.

Waste Oil Recovery

In northern communities where vehicles are used, diesels are generating electricity, or where other heavy machinery is operating, significant amounts of energy may be available as waste oil. Used crankcase oils, transmission fluids, and many other lube oils, have the energy content of heating oil. Yet, in most communities, these fluids are usually buried in dumps or landfills near the community or simply poured on the ground.

Specially designed oil furnaces can use this waste oil. All that is required is the installation of a collection/storage tank to hold the waste oils and the installation of an appropriate furnace. Storage tanks are essentially the same as the oil tanks currently used for conventional furnaces and would be expected to cost about the same. Furnaces designed to utilize waste oil are slightly more expensive than conventional furnaces. Smaller units appropriate to residential buildings cost on the order of $1,500 and large units appropriate to commercial or institutional buildings cost up to about $7,000.

Since the tank and furnace are an additional expense, the volume of waste oil will have to be large enough to offset these costs. It would not be appropriate to install a new furnace and additional tank for a single residence to burn the 40 litres of waste oil that might be available from the vehicles of the building occupants. However, a waste oil recovery system makes economic sense if a building occupant operates a number of heavy duty vehicles and also has a large space heating need.

This is often the case at highways maintenance facilities. Trucks, graders, snow plows and other heavy machinery can represent a substantial source of waste oil. As well, the facility is purchasing significant quantities of heating oil to provide space heat. Other buildings which are near a source of waste oil would also be potential candidates for the installation of waste oil furnaces. Larger community buildings would be the most suitable facilities including schools, community halls, recreational facilities, or other municipal buildings.

To determine if waste oil recovery makes sense in a particular community, it is necessary to first survey the sources and quantities of waste oil. As mentioned above, highway maintenance facilities are an obvious source, but also consider oil recovered from the diesel generators, service stations, garages, government motor pool vehicles, private automobiles, trucks, and other sources. If no records are available as to the amount of oil that is currently disposed, then estimate that approximately 70 percent of the oil used will be recoverable with a planned collection system. Therefore, if 10,000 litres of lube oils are used annually by a particular facility, then roughly 7,000 litres could be recovered and burned for space heating.

To keep the costs on a waste oil system within reason, transportation of the waste oil must be minimized. Therefore, it is advantageous to have the sources of waste oil and the collection point for waste oil in the same vicinity. If there is an appropriate building centrally located in the community, then it would be a simple matter of installing a storage tank with an exposed funnel for waste oil deposits. Government departments and the public would then be invited to dispose of their waste oils in this collection recepticle.
The waste oil furnace inside the building would

draw on waste oil when it is available and burn conventional fuel at other times.

To evaluate a waste oil system, estimate the litres of waste oil which could be burned and multiply that by the price per litre for heating fuel. If the annual value of the waste oil is great enough to justify the purchase of the waste oil system then the project should go ahead. The economic savings associated with waste oil combustion will be very attractive if the quantities available can meet more than 75% of the building heat requirement.

Solar Energy

Solar energy can provide economic benefits to every northern community. It is often difficult to determine the best way to use solar energy. Solar systems are typically classified as passive, active, and photovoltaic. Passive systems are the simplest in that they require no mechanical systems or external sources of energy.

Active systems are more complex in that they require another source of energy for pumping the solar heated fluids from solar panels to storage or heat exhangers.

Photovoltaic systems involve the direct conversion of sunshine to electricity. Photovoltaic systems are currently quite expensive and are considered experimental for any large scale application. It is not likely that large scale photovoltaic systems would be appropriate to the north, due to the long seasons without sunshine. However, photovoltaic cells have been used successfully to supply power in combination with battery packs for operating electronic equipment which must be stationed in remote locations. These applications generally involve telecommunication or ratio repeater stations, air and marine navigation and hazard lights, and similar installations where the power requirement is relatively low but the cost of hook-up to a power transmission grid would be prohibitive.

Another means of using energy from the sun is passive solar systems. Virtually every building and every community in Yukon could achieve oil reductions through increased application of passive solar. In passive heating systems, building modifications are made and insulation levels increased in order to capture as much solar energy as possible while at the same time minimizing heat losses. These modifications include increasing window areas on southern exposed walls and reducing window areas on northern walls. The windows should also be fitted with night insulating blankets, shutters or sliding doors which can be closed over the windows at night to minimize heat loss.

For existing buildings, retrofitting of these modifications can entail substantial cost and the advisability will be specific to each building. For new construction however, the cost of incorporating passive solar features can be quite minimal if the designer/builder is conscious of the advantages from the beginning. Every effort should be made to orient future buildings such that the bulk of the glass surface area faces south.

Community planning should incorporate designs for maximizing passive solar opportunities through the siting of future subdivisions and lots. Well planned passive solar buildings can save between 25% and 35% on oil purchases for space heating. For newly constructed buildings, the cost for incorporating passive solar features is quite small (i.e., less than 10%) while the energy savings can be quite significant.

In addition to obtaining more passive solar energy through southern windows, attached greenhouse structures on the southern walls of buildings can provide significant heat, as well as a supply of household vegetables. Such greenhouses can offer substantial benefits and are proven to be viable in the North. They can be incorporated into existing structures or new structures and can provide significant heat energy even in the late winter and early spring months.

Incorporating passive solar features into a community simply requires that the community planners and builders be conscious of the opportunities available.

Both passive and active heating systems have potential in the north. Active systems have been installed in the north for heating buildings, municipal swimmming pools, and even individual residences. It should be noted however that active solar for space heating has been found to be generally lacking in cost-effectiveness.

An active solar system entails the installation of solar collector panels, usually on the building roof or a nearby open area. Piping is then utilized to transport heated water from the collector panel to either a storage tank or heat exchange equipment inside the building. Mechanical pumps, usually driven by electricity, are required to move the fluids through the hot water distribution system. The heated water can be utilized in radiator type heat exchangers for space heating or can be used directly for domestic hot water or can be put through a heat exchanger to preheat domestic hot water.

These systems tend to be quite expensive when compared with conventional heating systems. The optimum situation occurs where there are large hot water demands during the summer months when most of the solar energy is available. For this reason, most of the larger scale active solar installations in the north have been for municipal swimming pools that are operated only in the summer. Other possible applications for active systems might include laundromats or washhouses, or shower facilities in tourism oriented areas.

Mayo, Yukon is one community which uses solar energy for the local swimming pool heating. Here, 130 square metres of solar collectors were installed to heat a 175 square metre pool. An important part of the solar heating system is the installation of a thermal blanket to reduce radiation and evaporation losses from the pool at night. Total project cost was about $20,000 and it is expected that the equivalent of about $3,000 in oil will be saved annually by such a system.

Another solar demonstration project is a domestic hot water solar system installed in Whitehorse for a residential building. In this case, a solar collector was installed for about $5,000 to supplement the electric fired hot water heater. In a community relying on diesel electricity, the value of the expected savings from this solar system is about $300 per year.

Hydro Electric Power

Hydro electric energy production is conceptually simple. It involves converting the energy of flowing water by placing a wheel or turbine in the flow, and connecting the turbine to an electric generator. Thus, the essential ingredient is flowing water. In general, the more water that is available, the more energy which can obtained from it.

There are economies of scale associated with hydro developments. Very large hydro generating stations in excess of 100 MW are associated with major rivers. Costs for the largest of these can be as low as about $2,500 per installed kW of capacity.

However, projects of this sort far exceed the demand or financial capabilities of small remote communities in the north. Northern communities would be more interested in the feasibility of "small hydro" installations, in communities that are currently dependent on diesel electric generation. The definition of "small hydro is not precise, but generally refers to installations of 5 MW or less.

The ideal situation for small hydro would be the natural occurrence of a lake with a stream outflow which drops down a steep face or waterfall. It would also be important that the lake be sufficiently deep so it does not freeze to the bottom during the winter. With this situation, a relatively modest dam might be constructed at the lake's outflow such that the water can be held back to raise the level in the lake slightly. The penstock could then drop down to the powerhouse over a relatively short distance. Circumstances other than those described above may entail more costly and complicated control structures and penstocks. This will make the feasibility of a small hydro installation more difficult to establish.

Further information regarding the feasibility criteria and economic factors of hydroelectric installations are included in Appendix: Hydroelectric Power.

Wind Energy

To make wind power feasible requires strong, steady and frequent winds. Even with a good wind resource, the technology for capturing and using wind power is expensive and is not a practical replacement for diesel generation in most communities. Very small Wind Energy Conversion Systems (WECS) of 2 kilowatts or less capacity have been installed across the country. However, they are generally appropriate to individual households in outlying areas, farms, and other isolated buildings where the loads are relatively small. In areas where diesel generation is extremely expensive, small wind generators have been found practical as supplementary sources of power provided the wind resource is available. Some communities in the Northwest Territories have wind generators.

Larger units capable of contributing to the electrical requirements of communities (e.g., 50 kW), are considered largely experimental and uneconomic at the present time. Since wind energy is not always available, it serves only as supplemental power where a diesel generator or other source is already in place. The wind generator can save fuel on the diesel set. This fuel savings is between 15¢ and 20¢ per wind generated kilowatt hour in most communities in the north. Demonstration projects in Canada indicate that wind turbines in the 50 kW capacity range would be expected to deliver energy at a cost closer to 50¢ per kilowatt hour.

To achieve this, the winds must be quite strong and frequent. For example, typical WECS's require a minimum wind speed of 20 kilometres per hour. When the winds are below 20, no energy is recovered from the machine. Rated output is achieved at between 35 and 55 kilometres per hour.

When the winds are less than about 40 km/h, the system does generate some electricty, but at less than peak output.

The capital costs for these systems cna be substantial. In general, the experience on demonstration projects in Canada has been that the installed cost would exceed $5,000 per kilowatt capacity. Thus, a 50 kW unit, appropriate for a small remote community, would cost over $250,000. This cost would not include any transmission lines.

Unless there is exceedingly strong winds quite near a community, wind energy is not likely to be practical.

Peat Energy Resource

Vast areas of peat bog occur in many regions north of Sixty. However, the quality and depths of this peat is poorly documented. Good quality dry peat can have energy content roughly equivalent to that of wood, but the problems of drainage and drying make peat much more difficult to use. Much of the peat in the north is located in continuous permafrost areas, which makes the drying particularly difficult. Ideally, the peat sod would be harvested and stored in the bog itself where air drying would reduce the moisture content from in excess of 85% down to about 55%. However, in areas that tend to have precipitation in the summer, air drying alone may be inadequate. In this case, the peat would have to be moved to storage sheds or warehouses for complete drying.

Even after a good drying period, the peat still has about 50% moisture content. This results in low combustion efficiencies. In home furnaces or airtight stoves, it could be expected that the combustion efficiency of peat would be only about 20%.

The harvesting of peat fuel could be pursued, if there is a high likelihood of being able to air dry the sod, and if there is no fuel wood available as an alternative fuel. If wood is available, the cost and effort involved in harvesting would be much less than would be the case for peat. Peat harvesting on a large scale basis requires large expenditures on preparation and drainage work in the peat bog, storage facilities and handling equipment.

Geothermal Power

Geothermal energy systems involve tapping hot water resources found beneath the earth's surface and using this natural heat source for hot water and space heating needs. Locating, defining and proving a geothermal resource entails much the same geotechnical and drilling expertise that is involved in oil and gas exploration. Therefore, very deep resources (i.e., more than 1000 metres) require substantial cost in their development. Small remote communities in the north do not have energy demands to justify the large expenditures involved in finding and developing a deep geothermal source. For example, the cost of developing a geothermal system would be about $1.5 million for just the wells, pumps, wellhead equipment and primary heat exchanger if the resource is between 1000 and 1500 metres below the surface. Transmission and distribution systems would add further costs. Near-surface manifestations of geothermal activity however, might indicate a low cost means of providing energy to the community. The principal criteria for geothermal energy is the occurrence of a natural hot spring in or near the community. Depending on the volume and temperature of water available from the source it may be feasible to develop a distribution piping system that would deliver energy to community buildings. The feasibility of the distribution system would involve much the same set of considerations which were discussed in the previous section on diesel waste heat recovery systems. The only significant difference is that the heat exchangers at the energy source draw heat from the geothermal water rather than the diesel jacket water system.

One example of use of geothermal energy in the north occurs at Mayo, Yukon. Here, the warm waters from a local hot spring are mixed with the town's water supply for freeze protection in the winter. A similar system is used in Whitehorse. Though this is a relatively small scale application of geothermal, it indicates the range of potential uses for this form of energy and can represent a considerable saving in energy expenditures.

If community planners suspect that geothermally heated waters are to be found in the vicinity of the community, it will probably be necessary to retain consultants who are experienced at evaluating these resources and determining the feasibility of distribution systems.

Biogas Energy Systems

It will take exceptional circumstances to make biogas energy systems feasible in the north.

Biogas digestors convert organic waste into methane gas through a fermenting process which occurs in the presence of heat. The gas produced has about half the energy content of natural gas. This gas can be used for space heating or cooking and with treatment, can even be burned in specially designed electric generators.

Although the technology is proven and methane digestors are in operation around the world, two of the principal ingredients to the process are lacking in most northern communities. Before biogas production can be considered, very large quantities of organic waste would be required. Generally, community sewage wastes alone would not be adequate. In addition, there would have to be some very large animal raising operation in the community or some other industry that generates a great deal of organic waste. As an indication of the relative volumes of waste necessary, a demonstration project in Prince Edward Island involved the installation of a methane digestor to utilize the hog manure from a 1,400 hog farm. The resulting energy from this waste was calculated to be worth about $8,900 per year. The installation cost of the digestor was $166,000.

Another difficulty with biogas production in the north is that the process itself requires heat. Optimum gas production occurs at about 30°-35°C. Thus, in the north it would be expected that in many circumstances, much of the energy produced by the digestor would actually have to be used to maintain adequate heat for the process.

There are additional problems with effluent disposal and waste collection which make northern biogas an unlikely alternative.

HOW CAN ENERGY ALTERNATIVES BE IMPLEMENTED?

For the most part, determination of the technical and economic feasibility of an alternative energy supply will entail expert advice and assistance. If the preliminary review of potential resources indicates that development of a particular scheme shows promise, the next step is to commission a feasibility study. The Energy Planning Committee should contact regional and/or federal government departments with energy programs. These departments can provide assistance in preparing terms of reference for the study and contacts with consultants who would be qualified for the work. Government programs may also be available to provide some funding assistance for the feasibility work.

If the consultants conclude that the project is viable, then the next step is to proceed with detailed design and cost estimates. At the same time, the energy planning committee must address the financing and institutional questions associated with the project. Some of these will include:

- How will the project be funded?
- Who will own the development?
- Who will operate it?
- Is there a ready market for the energy?
- Who needs to approve the project?
- Is government assistance available?

These matters must be dealt with in much the same fashion as any other community or municipal capital project. Again, the expertise of various government officials and consultants will be available for many aspects of the project implementation.

STEP 10: DEVELOP AN ONGOING ENERGY ACCOUNTING SYSTEM

In Step 3 of the community energy plan, an action plan for implementing conservation was developed by ranking buildings by the energy performance index. The performance index was calculated from fuel and electricity records. This same method is used to chart the performance of buildings on a continuing basis. This procedure forms the basis for the Energy Accounting System.

An ongoing energy accounting system is the most important working tool of the community energy plan. The purpose of the energy accounting system is to provide a continuous record of energy use, so that the community can set targets for energy savings. The energy accounting system can be effectively used to establish an "energy budget" for individual buildings, or for a group of buildings in the community.

An energy budget is a target for building energy performance over a specified period of time. The energy budget is based on the performance indices which are calculated for each building through the Energy Accounting System.

WHAT ARE THE BENEFITS OF AN ENERGY ACCOUNTING SYSTEM?

Energy use in a building can be compared to the operation of an automobile. To increase performance and to prevent problems with operation, a process of regular maintenance and attention is required.

For many building owners, a major barrier to energy conservation is the lack of any way to measure actual savings, or confirm a change in building performance which results from conservation measures.

Without some method of correlating energy use with climate, energy efficiency is subject to the opinion of individual building owners and operators. These opinions inevitably vary, in terms of how harsh one winter is compared to another, and how efficiently the building is operated.

Comparing energy costs from year to year will not accurately show savings. The cost of energy from year to year is very much dependent on climate and changes in the cost of fuel.

The energy accounting system provides answers for building owners and operators by producing month by month picture of energy use and performance. The impact of effective conservation measures shows on an energy graph as a decrease in energy consumption and an increase in performance.

A well-planned energy accounting system takes the guesswork out of energy management. It can provide a schedule for energy management and maintenance measures to get the most out of every energy dollar.

An additional benefit of the energy accounting system is that it can also determine total energy use for a specific sector or group of buildings in the community, government or municipal buildings could be presented on a summary page to illustrate trends in energy use patterns for a group of buildings over the heating season. This summary method can be useful for evaluating the benefits of community energy planning to a specific sector in the community.

Some sectors will undoubtably see greater benefits to the energy accounting system than others. The benefits to the building owner or operator may be the most significant in the commercial or residential sectors. In these sectors, every dollar in energy savings means more money available for other investments or activities. In these cases, the building owners or operators may put considerable efforts into increasing energy efficiency to accummulate benefits in energy savings.

Building owners in the commercial and residential sectors may wish to confidentially subscribe to an energy accounting service rather than sharing operating procedures with the public.

HOW IS AN ENERGY ACCOUNTING SYSTEM DEVELOPED AND MAINTAINED?

There are specific methods which a community may utilize for monitoring reduced energy consumption over the long term. The methods developed in Step

7 of the Community Energy Plan provide an effective basis for developing an ongoing energy accounting system.

Performance indices are maintained on a monthly basis. To be consistent with earlier calculations, the "performance indices" calculated for the energy accounting system should represent the number of energy units (megajoules) consumed, per heated volume of space (m^3), per degree day (DD).

The analysis should include a plot of the performance index of each building in graphic form, so monthly changes in performance ratings can be seen at a glance.

Like many organizations which set up contractual arrangements for ongoing financial accounting, the energy accounting system could be developed in a contract agreement with experienced energy analysts.

The scope of work would include gathering energy bills and climate records, and calculating the number of degree days which accumulate between documented consumption points (billing dates) for each building. With these data, the current performance index is calculated for the building.

The computerized tabulation of performance indices for each building can be reviewed at regular intervals with the building owner or operator provide guidance and advice, as well as information about available grants, low-interest loans, and training programs.

Community Energy Planning takes time and dedication on the part of key people in the community and in government. By following the ten steps in this handbook, a community can undertake conservation measures, develop methods of monitoring energy performance, and evaluate alternative and supplementary energy supply sources. Changing economic factors, fuel costs, and climate can affect the applicability of specific recommendations. These effects can be minimized through an ongoing accounting system.

With an ongoing energy accounting system the energy plan may be integrated as one part of a five year developmental plan for the community, or it may be undertaken on a separate basis. Either way, it can provide valuable economic information for planning new construction, retrofit, or reclassification of specific buildings for a different use.

Any community which is concerned with the future cost and viability of energy supply, can benefit from the implementation of Community Energy Planning.

APPENDIX 1: WASTE HEAT RECOVERY

While the mechanical or hardware specifications of a waste heat recovery system can be quite simple, the planning and assessment of such systems or, for that matter, any centralized energy system, can be far more complex and subtle.

The first step of the evaluation involves determination of the total energy available and the pattern of supply.

Monthly fuel consumption of the diesels or the monthly total generation is obtained from the operator of the diesel generator. Records more detailed than monthly (i.e. daily or even hourly) will allow more precise analysis of the energy supply.

An analysis of the potential recoverable energy is shown in the following example:

Assume: Fuel consumption = 10,000 liters for month
Fuel energy content = 36 MJ per liter

Calculate:

- Heat available from jacket water:
  (0.3 x 36) x 10,000 = 108,000 MJ (108 GJ)
- Heat available from exhaust:

  (0.15 x 36) x 10,000 = 54,000 MJ (54 GJ)/month
- Heat available from jacket water and exhaust:

108,000 + 54,000 = 162,000 MJ (162 GJ)/month

If the data supplied by the diesel operator is in kWh, then the calculation is as follows:

Assume: Generating efficiency - 3 kWh per liter

Electric generation = 30,000 kWh for month

Calculate:

Fuel consumption for month:

$$\frac{30,000}{3} = 10,000 \text{ liters for month}$$

Then proceed with calculations as in previous example.

Once this set of calculations has been performed for each month, the pattern of heat availability will be apparent. Since the heat output is directly proportional with the electrical generation, the typical pattern would be that more heat is available in the winter (when lights are on longer, occupants are inside more, water heaters require more energy, block heaters are used, etc.) than in the summer.

To maximize the oil savings provided by a heat recovery system, buildings should be connected to the system until the loads will at all times exceed the supply. Then, all of the available heat would be utilized. However, cost may limit the objective of maximizing system utilization. As more buildings are added to the system, longer pipe runs will be required; larger pipes, pumps and heat exchangers may be necessary. At some point the incremental utilization will become quite small while the additional expenditure is becoming larger and larger. Thus, maximizing system utilization must be economically justified.

The system costs which will be most sensitive to local factors are the central plant equipment costs which depend on how many diesels are involved, how much storage is required, pump size specifications and building space needs. Trenching and pipelaying costs will depend primarily upon the existence of permafrost, soil conditions, road crossings, watercourse crossings and gravel availability.

Before determining the potential for a district heating system, it is necessary to know the heating loads of buildings to be considered. (Hot water heating loads should be included also.) The process involves adding loads from the diesel plant such that more and more buildings are included in the system. As a first check, buildings should be added until all of the available heat from the diesel is taken up by the building loads, that is, the connected load would exceed the supply. This is the condition of 100% recovery system utilization.

Then, working backwards, determine on a building by building basis whether connection of the outermost buildings is justified. Assume that the building that is furthest from the diesel required

100 m of additional pipe connection. It is a residential building so the service connection would be $500 and the trenchings would be $50 per meter. Thus, it can be calculated that the cost of including this building will be about $8,000.

Pursuing this example, also assume that analysis of the heat supply from the system and the building's heat demand indicate that about 10 GJ of waste heat energy will be available to displace oil heating. The value then of the savings on oil purchases each year would be found as follows:

(10 GJ x 1000 MJ/GJ) = 10 000 MJ
(37.6 MJ/liter x .6 furnace efficiency) =
22.56 MJ/liter
10,000 MJ ÷ 22.56 MJ/liter = 443 liters
443 liters x $0.46/liter = $203.90

Therefore, for an investment of $8,000, an annual savings of about $204 can be realized. Two simple ways of determining whether this is an adequate return involve calculation of the payback period and the returns on an alternative investment.

The payback in this case is:
$8,000 ÷ $204/year = 39.2 years

A straight forward alternative might be to simply put the $8,000 in a term deposit earning 10 percent interest. The annual return would be:

$8,000 x .1 = $800

Neither of these feasibility tests indicate that the building should be connected to the system. Thirty nine years is a very long time to wait to recover the investment, and the low-risk alternative of putting the money in the bank is significantly more attractive.

The next step in the trial and error procedure then would be to step back to the next most outlying building and perform the same analysis. This is done until the group of buildings for which connection is justified is determined. If the number of these becomes exceedingly small, then the entire system may fail to meet feasibility criteria since the accumulated oil savings may not be great enough to even justify the installation of the central plant, let alone the distribution system.

Judgement, data analysis, risk attitudes and the level of uncertainties in the estimates used will influence the assessment of system feasibility. However, the examples provided above should provide some tools for at least addressing the potential for waste heat recovery at a preliminary level.

APPENDIX 2: HYDRO ELECTRIC POWER

To determine the approximate capacity required in a community, the installed diesel generation capacity should be checked. If the historical peak demand for the community is available this would be a better indicator. If for example, a community has 800 kW of installed capacity and the peak demand has been 690 kW, then the necessary hydro capacity would be in the 700 to 800 kW range approximately. As a simple rule of thumb, the energy potential of a given stream can be determined if the vertical drop of the water and the flow rate of the water are known. The formula for this calculation is:

$$\text{Power (kW)} = 7.0 \times Q \times H$$

where, Q = water flow rate in m^3/s
H = head drop of water in meters

The natural vertical drop of a stream can be enhanced by a control structure which holds back the water to store energy and effectively raise the level of the water at the top of the drop. A penstock (a pipeline) would carry water from the control structure (dam) down to the powerhouse containing the generators. With these facilities installed, the available power would be determined by the flow and head in the penstock rather than that which was found on the original stream.

There is no simple formula for estimating the costs of dams and penstocks for small hydro.

These will be entirely site dependent and would be dictated by the terrain, access, need for storage, and the flows to be handled.

The need for proximity to the community is important when scanning the surrounding area for potential hydro opportunities. An integral part of a hydro electric generating system is the transmission line from the power house to the end user. The reason many communities in the north are dependent on diesel generation is that it would be excessively costly to run transmission lines from the existing hydroelectric grid to the community. The same constraint would apply with respect to the transmission from a dedicated small hydro site to the community. Depending on terrain, length, and size, transmission lines can cost between $40,000 and $100,000 per kilometer. On average, a household in the north consumes 15,000 kWhs per year. In a diesel community, the value of this electricity can be as much as $3,000 per year. To reduce those costs it might be reasonable to consider a project if the savings would payback the initial cost in 10 years. Also assuming that the transmission line would be about half the cost of a small hydro development, then it would be reasonable to consider projects which would have as much as 0.2 km of transmission line per household in the community. This figure can be used as a rough rule of thumb to establish the maximum radius within which potential small hydro sites might be considered for the community. For example, if a community has 50 households and no other significant electric load requirements, then it would be reasonable to consider hydro sites within about 10 km of the community. (50 x .2 = 10)

To pursue the potential of a small hydro site beyond this preliminary identification stage, detailed analysis would be required. Necessary data include precipitation and stream flow records, the size of the catchment basin upstream of the control structure, for preliminary design studies and capital cost estimates. There is no simple way to arrive at firm conclusions about the potential without going through these steps. However, if preliminary planning indicates a site that warrants this next preliminary design step, power engineering consultants can provide an indication of feasibility with a minimum of expensive field work. This would be the appropriate next phase of the assessment.

Hydroelectric installations tend to be relatively high in capital cost, but quite low in operating costs. This is in contrast to many other technologies such as diesel or wood fired systems where the operating costs, that is the supply of the fuel, tends to be the significant expenditure. When a project is expensive to build, the optimum economic returns are achieved when it is used as much as possible.

Ultimately, the feasibility of a small hydro scheme will depend on whether the total savings from oil not used, is greater than annual interest and amortization of capital costs for the project.

To determine the magnitude of the savings, it will be necessary to go through the analysis of building energy demands described in earlier sections of the Handbook. To determine the costs, some consulting assistance will be required.

Small hydro technology is improving and if the natural conditions (i.e., lake and stream) are available, the costs for installation are becoming more reasonable. Hydro represents an excellent oil reduction or off-oil alternative given the right circumstances. Because such installations represent substantial capital costs, however, careful planning and assessment is crucial.